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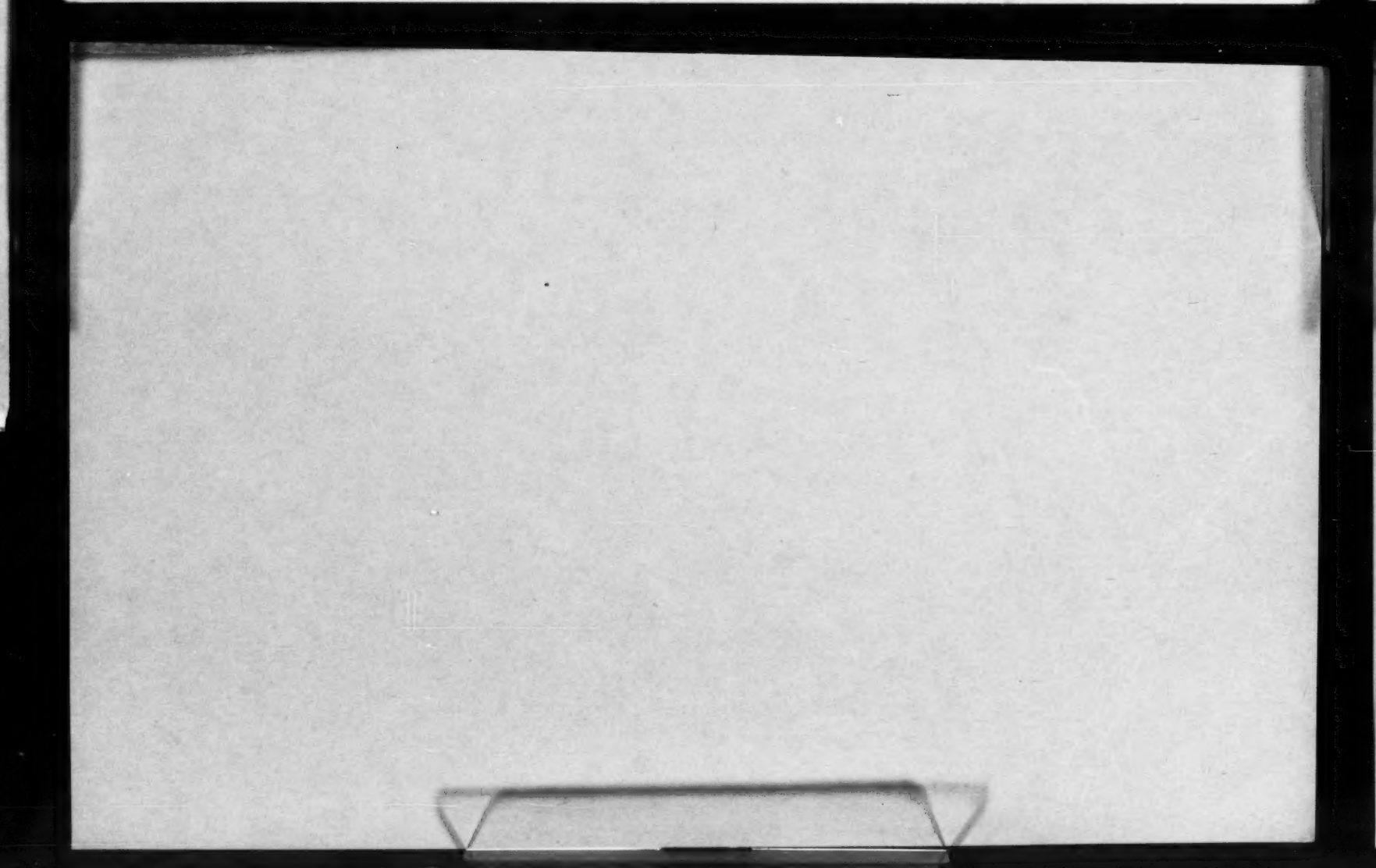

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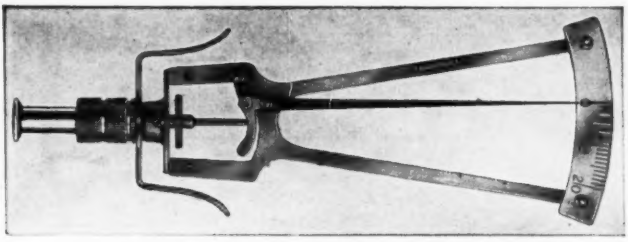

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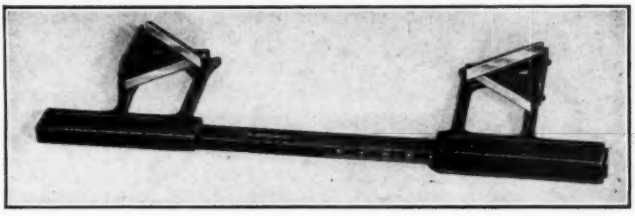

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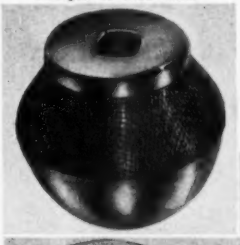

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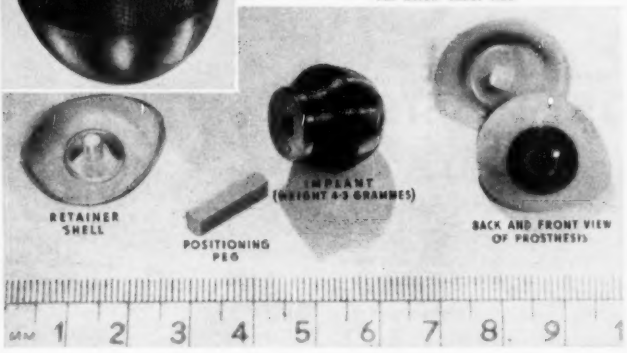

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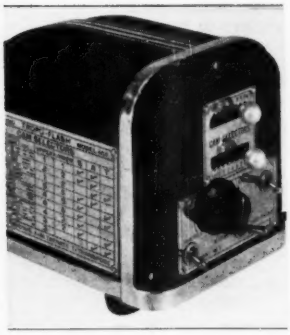

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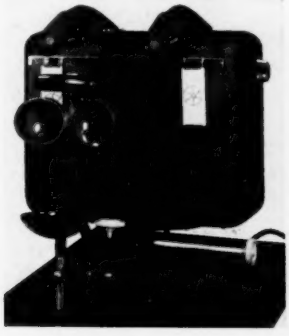

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AN OPERATION FOR PTOSIS UTILIZING THE SUPERIOR RECTUS MUSCLE

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HACKENSACK, N. J.

IN VIEW of the fact that more than eighty operations have been proposed for the treatment of ptosis, there would seem to be little justification for sponsoring another. However, it might be argued that the large number of procedures already available is adequate proof that none is eminently successful in all cases. For example, resection of the levator palpebrae superioris usually results in failure when levator action is absent; suspension of the upper lid from the brow produces lagophthalmos in looking down, while utilization of the superior rectus muscle causes a notch in the lid or hypotropia or both. It is obvious, therefore, that none of these procedures can give a satisfacory result in all cases. This is especially true of complete ptosis, i. e., complete paralysis of the levator.

OPERATION FOR PTOSIS UTILIZING SUPERIOR RECTUS MUSCLE

INDICATIONS FOR OPERATION

The operation proposed here is not recommended for all types of ptosis but is designed only for those cases in which resection of the levator palpebrae is not indicated.[1] Specifically, this operation is useful in four types of ptosis: (1) complete ptosis[2] with normal superior rectus muscles, (2) complete ptosis with weak superior rectus muscles, (3) ptosis associated with the jaw-winking phenomenon of Marcus Gunn and (4) complete ptosis associated with blepharophimosis.

Complete Ptosis with Normal Superior Rectus Muscle.—In a recent survey[3] of 200 cases of congenital ptosis, it was shown that in 74 per cent of the 200 cases normal superior rectus muscles were associated with absence of levator action. Cases of this type are considered by some

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1. In more than 50 per cent of cases of congenital ptosis levator action is sufficient to warrant resection of the levator muscle as the operation of choice.

2. By complete ptosis I mean ptosis with no levator action present. This condition is characterized by absence of elevation of the upper lid in looking up, by lack of an upper lid fold and by narrowing of the palpebral fissure in looking up.

3. Berke, R. N.: Congenital Ptosis: A Classification of Two Hundred Cases, Arch. Ophth. **41**:188-197 (Feb.) 1949.

surgeons to be ideal for the Motais-Parinaud operation, this operation being based on the assumption that a normal superior rectus muscle can raise both the globe and the upper lid without complication. That a normal superior rectus cannot perform this dual task satisfactorily was demonstrated in a study of the postoperative results in 35 cases in which the Motais-Parinaud operation was done.[4] In at least 75 per cent of the cases postoperative hypotropia developed because of weakness of the superior rectus induced by the operation. Therefore, if utilization of the lifting power of a normal superior rectus muscle to correct ptosis induces a weakness of this muscle, it would seem logical to foresee this complication and to shorten the muscle to increase its lifting power when doing this operation for ptosis. The operation described here was designed to meet this need. It is a modified Motais procedure and consists in a combination of two operations: an operation on the globe to shorten the superior rectus, combined with suspension of the lid from the superior rectus muscle to correct ptosis.

Most ophthalmologists avoid operations on the superior rectus muscle because such operations are seldom indicated and the results, as reported in the literature, are variable and confusing. One would expect that a 5 to 6 mm. resection of a normal superior rectus muscle, as recommended in the operation for ptosis presented here, would tend to produce overaction of this muscle, with troublesome postoperative diplopia. However, this does not occur because the added weight of the lid counterbalances this tendency. Therefore, when performing the operation advocated here, the surgeon need not feel any anxiety regarding the resulting diplopia or a disfiguring hypertropia. I have done this operation four times on a normal superior rectus muscle without inducing overaction or diplopia in a single case (cases 1 to 4).

Complete Ptosis with Weak Superior Rectus Muscle.—In the report [3] previously referred to, it was further shown that in about 18 per cent of the 200 cases complete ptosis was combined with a weak superior rectus muscle. This type presents a difficult surgical problem because, in the absence of levator action, resection of the levator muscle usually results in failure, and because the Motais-Parinaud operation, done on an already weak superior rectus muscle, only increases the hypotropia present. For these reasons, Wiener [5] advocated the operation utilizing the frontalis muscle in such cases. On the other hand, Wheeler [6] avoided doing the frontalis muscle operation because of the unsatisfactory cosmetic and functional results obtained. Instead, he resected the

4. Berke, R. N.: Motais-Parinaud Type of Operation for Ptosis, Arch. Ophth. **41**:324-333 (March) 1949.

5. Wiener, M.: Surgical Correction of Ocular Disfigurements, Surg., Gynec. & Obst. **58**:390-393, 1934.

6. Wheeler, J. M.: Correction of Ptosis by Attachment of Strip of Orbicularis Muscle to Superior Rectus Muscle, Arch. Ophth. **21**:1-7 (Jan.) 1939.

superior rectus and/or the inferior oblique as indicated to elevate the globe and at a later date performed a Motais operation to correct the ptosis. After a few unhappy experiences with this plan, Kirby [7] advocated the frontalis muscle operation. White [8] insisted, however, that the hypotropia should be remedied before the ptosis was corrected.

I have performed the present operation ten times on eyes with weak superior rectus muscles, with improvement in the ptosis and the hypotropia in every case (cases 5 to 14).

Ptosis with the Jaw-Winking Phenomenon.—In about 6 per cent [3] of all cases of congenital ptosis the jaw-winking phenomenon of Marcus Gunn is present, in some with and in some without normal ocular elevation. The ptosis here is always unilateral and may be complete or incomplete. The most characteristic feature, the jaw-winking phenomenon, is brought out when the mandible is depressed, as in eating, or when it is moved to the side opposite the ptosis. When the jaw is in either of these two positions, the upper lid of the affected side moves upward, sometimes higher than the lid on the sound side, especially when the eyes are directed down.

When the superior rectus is weak in a case of the jaw-winking phenomenon, one must elevate the globe, correct the ptosis and abolish the jaw-winking reflex. These three objectives can be acheived in one sitting by the operation described here. First, the jaw-winking phenomenon is abolished by excising a strip of the tendon of the levator muscle thus converting what is usually an intermittent, incomplete ptosis into a complete one. Then the superior rectus is shortened to correct the hypotropia, and, at the same time, the ptosis is corrected by the operation described here This procedure, performed in 5 cases, has been followed with a good result in each case (cases 15 to 19).

Ptosis Associated with Blepharophimosis.—This type of ptosis comprises about 3 per cent of all cases of congenital ptosis [3] and is characterized by abnormally short palpebral fissures, a great intercanthal distance over the bridge of the nose between the inner canthi and ptosis. In about 60 per cent [5] of these cases enough levator action is present to justify resection of the levator muscle. In the other 40 per cent the ptosis must be corrected by utilizing the lifting power of either the superior rectus or the frontalis muscle

Before correcting the ptosis, the blepharophimosis and the abnormally great distance between the inner canthi must be remedied. The

7. Kirby, D. B.: Paralysis of Ocular Elevation With and Without Ptosis, Tr. Am. Ophth. Soc. **43**:218-239, 1945; Arch. Ophth. **35**:199-217 (March) 1946.

8. White, J. W.: Choice of Fixating Eye in Paralytic and Non-Paralytic Strabismus, Am. J. Ophth. **27**:817-819 (Aug.) 1944; Paralysis of the Superior Rectus and the Inferior Oblique Muscles in the Same Eye, Arch. Ophth. **27**:366-371 (Feb.) 1942.

palpebral fissures can be lengthened by an external canthoplasty, and the distance between the inner canthi can be decreased by shortening the inner and tenotomizing the outer canthal ligaments. This plan of procedure was followed in 1 case with a fairly good result (case 20)

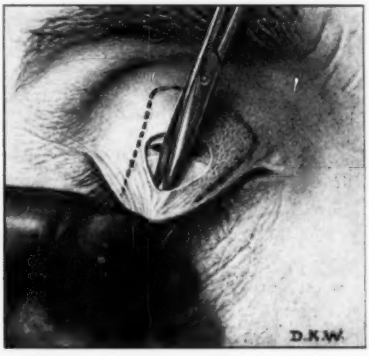

Fig. 1.—An incision 20 to 25 mm. long has been made through the skin and orbicularis muscle. A horn plate is used to support the lid while the skin and orbicularis are reflected down to the cilia. The incision through the conjunctiva above the tarsus can be seen behind the scissors.

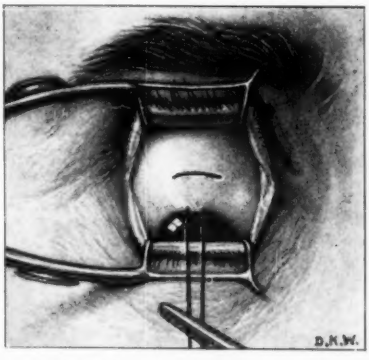

Fig. 2.—A traction suture has been passed through the limbus to pull the globe down, and an incision is made through the conjunctiva over the insertion of the superior rectus muscle.

TECHNIC OF OPERATION

1. With the patient under general anesthesia, an incision is made through the skin and the orbicularis muscle of the upper lid for a distance of 25 mm. exactly where the upper lid fold should be to match that of the fellow eye.

2. The lower part of the skin flap with the orbicularis fibers is reflected from the tarsus down to the lashes and the upper portion of the flap is reflected upward to the upper edge of the tarsus. Here, an incision 10 mm. wide is made through the conjunctiva into the conjunctival sac (fig. 1).

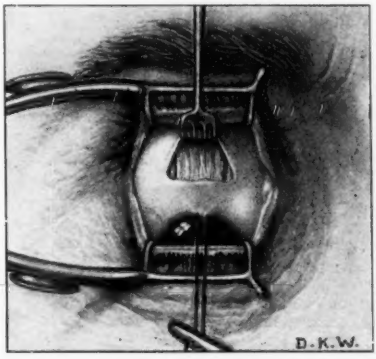

Fig. 3.—The superior rectus is exposed and freed from Tenon's capsule for a distance of 6 to 10 mm., care being taken not to sever the reflected tendon of the superior oblique muscle, which lies directly under it.

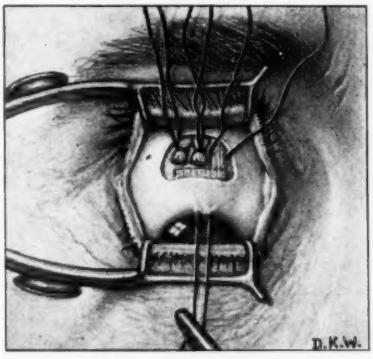

Fig. 4.—Three double-armed atraumatic 0000 plain surgical gut sutures are passed through the lateral, the middle and the medial third of the superior rectus tendon 2 or 3 mm. from its insertion and tied, leaving 2 mm. of tendon anterior to each knot. This may be done with or without the aid of a muscle clamp. If a muscle clamp is used in resecting the superior rectus, then it is more convenient to place these sutures after the muscle has been resected.

3. A speculum is then inserted, the globe pulled down by a silk suture inserted through the limbus at 12 o'clock and an incision made through the conjunctiva over the insertion of the superior rectus muscle (fig. 2).

4. After the superior rectus muscle has been exposed for 8 to 10 mm. posteriorly (fig. 3), three double-armed, plain 0000 surgical gut sutures are passed through the medial, the middle and the lateral third of the superior rectus

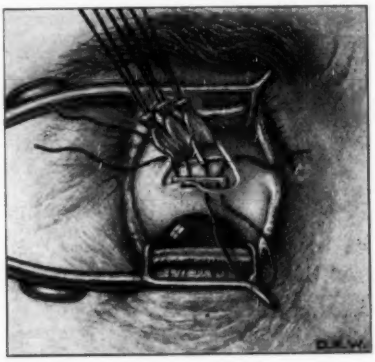

Fig. 5.—After the superior rectus is severed from the globe (with or without the aid of a muscle clamp) two double-armed 0000 chromic surgical gut sutures are passed first through the lower lip of the conjunctiva, then through the muscle stump attached to the sclera, then through the superior rectus at the proper height and, finally, through the upper lip of the conjunctiva and tied. Note the tendon of the superior oblique under the superior rectus muscle.

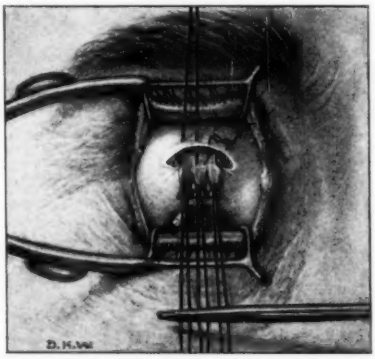

Fig. 6.—The two double-armed chromic surgical gut sutures are tied, leaving exposed the three tongues of the superior rectus muscle.

tendon and tied to leave a 2 mm. stump anterior to the sutures (fig. 4). This may be done with or without the aid of a muscle clamp.

5. The tendon of the superior rectus muscle is then severed from the globe and the muscle shortened 5 to 10 mm. (depending on the weakness of the muscle) by passing two double-armed 0000 chromic surgical gut sutures first through

the lower lip of the conjunctiva (fig. 5), then through the muscle stump attached to the sclera, then through the superior rectus at the proper height and, finally, through the upper lip of the conjunctiva. When tied, these sutures close the conjunctival wound, effect a shortening of the superior rectus and leave an exposed tongue of muscle 5 to 10 mm. long (fig. 6).

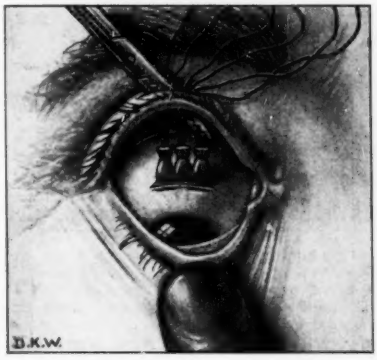

Fig. 7.—The three tongues of the superior rectus muscle are pulled forward through the previously made incision in the conjunctiva to the anterior surface of the tarsus.

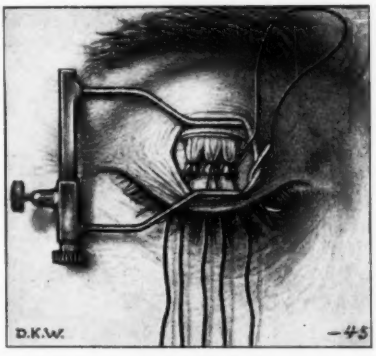

Fig. 8.—The three tongues of the superior rectus muscle are spread out on the anterior surface of the tarsus, and the three double-armed sutures are passed through the gray line of the upper lid so that each set of sutures is 5 to 6 mm. apart.

6. The exposed tongue of the superior rectus is then split into three smaller tongues, corresponding to the three previously placed plain surgical gut sutures, and pulled through the opening in the conjunctiva (fig. 7) on to the anterior surface of the tarsus, where the transplanted muscle tongues are spread out (fig. 8).

Fig. 9.—Each of the three double-armed sutures is tied with one knot to study the effect. When the lid has been elevated to the proper height and the curve of the upper lid has been adjusted to match that of the opposite eye, a second knot is tied and the sutures are cut short. Then three or four sutures are passed through the skin and under the transplanted tongue of the superior rectus as illustrated in figure 10. When tied, these sutures anchor the skin to the transplanted tongue, prevent entropion and create a natural-appearing upper lid fold.

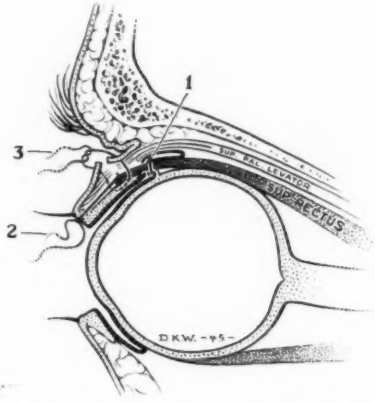

Fig. 10.—Sagittal section of the lids and globe illustrates the position of the three sets of sutures:

(*1*) The two chromic surgical gut sutures which shorten the superior rectus and close the conjunctival wound;

(*2*) the three plain surgical gut sutures which anchor the transplanted tongues of the superior rectus to the anterior surface of the tarsus;

(*3*) the sutures (silk or gut) which close the skin wound, produce an upper lid fold and support the skin and lashes, thus preventing entropion.

7. The six needles of the three double-armed surgical gut sutures are then passed between the orbicularis and the tarsus through the gray line of the upper lid, so that each pair of sutures is 5 or 6 mm. apart (fig. 8). The sutures should not be passed through the lashes, else the lashes may grow distorted after operation.

8. The three sets of sutures are tied with one knot at first to permit a study of the effect. When the lid margin has been adjusted to the proper height and curve to match that of the fellow eye, a second knot is tied (fig. 9) and the sutures are cut short. An overcorrection of 2 mm. is necessary to counteract the postoperative reaction.

9. The skin wound is closed by means of three or more 000000 silk sutures (0000 plain surgical gut sutures in children), passed first through the lower skin flap, then under the three transplanted tongues of the superior rectus and, finally, through the upper skin flap (fig. 10). When tied, these sutures produce a natural-appearing upper lid fold and anchor the skin to the transplanted tongues of the superior rectus, thus preventing the lashes from turning in against the cornea.

10. The suture in the limbus is now removed; a Frost silk suture is passed through the lower lid, and the latter is pulled up to cover the cornea.

11. A petrolatum gauze dressing is applied with moderate pressure to keep down the edema.

AFTER-TREATMENT

The dressing and the Frost suture are removed on the fifth day, at which time the surgical gut sutures in the skin and lid margin are generally absorbed, leaving a natural-appearing lid margin and upper lid fold. It is important to protect the cornea against drying or injury for the first few days after removal of the dressing, for these corneas are more sensitive to exposure than normal corneas, having always been covered by the upper lid and never before having been completely exposed to the air. Unless these corneas are tested once a day with fluorescein and examined under the slit lamp, superficial staining and irritation may be permitted to develop. This condition can always be prevented if an anti-drying agent, such as 1 per cent methyl cellulose, is instilled into the conjunctival sac three or four times a day and again at bedtime. If staining should develop in spite of this precaution, it may be necessary to pull the lower lid up over the cornea by a strip of adhesive plaster at night. After a few weeks, this precaution and use of the methyl cellulose drops can be discontinued.

ADVANTAGES AND DISADVANTAGES

The operation presents the following advantages:

1. The superior rectus muscle can be used even though it is paralyzed.

2. Slipping of the transplanted muscle tongue is reduced to a minimum, thus assuring success oftener.

3. A smooth curve of the upper lid results, thus eliminating the notch so often produced by the classic Motais procedure.

4. Entropion, or turning in of the lashes, of the upper lid is prevented.

5. A good upper lid fold, matching that of the fellow eye, is produced.

6. Postoperative hypotropia is prevented or greatly reduced.

7. The operation can be used even for very young children because the entire width of the superior rectus muscle is used.

8. The lid moves up and down synchronously with the globe.

9. The operation is tedious and exacting, but not difficult.

The disadvantages are that (1) normal winking is interfered with and (2) lagophthalmos is present in sleep. Neither of these complications is serious. The absence of normal winking is scarcely noticed, especially by the layman. The lagophthalmos during sleep gives the surgeon some concern because of the danger of drying and ulceration of the cornea. I believe that this danger has been overemphasized, for in not one of the present cases has it been a serious problem Every cornea has gradually adjusted itself to exposure without ulceration or scarring. I believe this is because a careful vigilance was maintained the first few days after operation and because methyl cellulose was used four or five times a day for two or three weeks after operation. Also, many patients learn a modified Bell's phenomenon, which protects the cornea against exposure during sleep. I have observed several cases in which the patient has learned to turn his cornea on the side of the lagophthalmos under the outer canthus when closing his eyes, thus preventing exposure. This is something the patient has learned without conscious effort on his part so far as I know. In only 1 case (case 2) did ulceration of the cornea develop, and this occurred in a boy who had been struck in the eye three days previously with a snowball.

Even though the surgeon cannot attain perfect results in all cases of ptosis, nevertheless, he can generally improve the patient's appearance functionally and cosmetically. No one can create levator muscle tissue where it does not exist. All any surgeon can reasonably hope to accomplish in these trying cases is to utilize the tissues available to the best advantage. With this in mind, I believe the operation described here will fill an urgent need in the surgical treatment of ptosis.

REPORT OF CASES

Case 1.—On Nov. 9, 1945, D. G., aged 2 years, was brought to the ophthalmology department of the Vanderbilt Clinic with a history of ptosis of the right upper lid since birth (fig. 11). Examination showed complete ptosis of the right eye with little or no levator action and with normal extraocular movements.

On November 19, a resection of the levator palpabrae muscle was done on the right eye, with little or no improvement in the ptosis. On April 25, 1947, therefore, the superior rectus muscle was shortened 5 mm. and the upper lid margin raised to 1 mm. below the limbus according to the technic described here. At the first dressing, four days later, the upper lid had fallen 2 mm. and now overlapped the cornea 3 mm. Slight staining of the cornea developed, but disappeared after use of methyl cellulose for twelve hours.

When the patient was last seen, on May 20, 1948, the ptosis was well corrected, a good upper lid fold was present, the cornea did not stain and the lids moved up and down synchronously with the globe. However, there was slight sagging of the lateral half of the right upper lid. This was attributed to pulling out of the suture in the lateral muscle tongue.

Case 2.—Master M. S., aged 8, came to the ophthalmology department of the Vanderbilt Clinic in April 1947 with bilateral congenital ptosis (fig. 12). Examination showed vision of 20/50 in the right eye and 20/40 in the left eye uncorrected. He had complete bilateral ptosis, but by contracting the frontalis muscle and raising his chin he could see straight ahead in the horizontal plane. No weakness was noted in any of the extraocular muscles.

On April 22, 1947 both superior rectus muscles were shortened 5 mm. and the muscle tongues carried forward into the upper lids, according to the technic

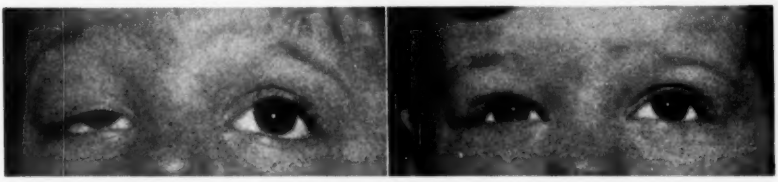

Fig. 11 (case 1).—Complete ptosis before operation. One millimeter of ptosis and slight edema of the right upper lid remain after operation. Note that the right lower lid is higher than the left, thus narrowing the right palpebral fissure.

Fig. 12 (case 2).—Before operation the patient had to tilt his head backward in order to see straight ahead. After operation the ptosis was well corrected, and normal-appearing upper lid folds were present. Diplopia was absent.

previously described. On the fifth postoperative day the Frost sutures were removed, after which faint staining of each cornea developed. This cleared up promptly in a day or two with the use of methyl cellulose. One month after the operation the patient presented the appearance shown in figure 12. At this time some weakness of each superior rectus could be brought out in the extreme superior temporal fields, but the patient did not complain of diplopia.

Ten months after the operation the child reported to the clinic with an ulcer of the left cornea, stating that a few days before he had been struck in this eye with a piece of snow. The ulcer cleared up in three weeks with the use of liquid petrolatum and a patch, leaving a thin scar adjacent to the pupillary area.

Comment.—This case is the only one in this series in which a corneal ulcer with scarring developed after operation from any cause. The

ulcer was definitely caused by the injury and not by exposure; and the ulcer cannot be attributed to the operation, for the patient has always been able to close his eyes voluntarily, with effort.

It should be noted that, even though each superior rectus muscle was normal before operation, no overaction occurred after both muscles were shortened. As a matter of fact, just the reverse effect was present after operation, for slight weakness was detectable in extreme rotation into the field of action of each superior rectus. Therefore, it would seem that resection of the superior rectus muscle is indicated in all cases of complete ptosis in which this muscle is used to support the lid, even when the superior rectus is normal. When the superior rectus is paralyzed or paretic, more muscle tissue (8 to 12 mm.) should be resected.

Case 3.—G. M. C., a youth aged 18, consulted Dr. Gordon M. Bruce on Nov. 18, 1947 because of bilateral ptosis, greater in the right eye, which had been present since birth. Examination showed his vision to be 20/20 in each eye with correction. The ptosis of the right eye measured 3 mm. with eyes down,

Fig. 13 (case 3).—Bilateral ptosis, greater in the right eye. Note in the picture before operation that both eyebrows are elevated in an attempt to uncover the right pupil. After operation, this muscle action of the frontalis is absent, a good upper lid fold is present and the ptosis is well corrected. The left upper lid will be raised at a later date to correspond to the right.

5 mm. with eyes in the primary position and 3 mm. with eyes up. Action of the levator muscle was absent in the right eye but was good in the left eye. Extraocular motility and the fundi were normal.

On December 16, Dr. Bruce shortened the right superior rectus 6 mm. and carried the muscle tongue forward into the tissues of the upper lid, according to the technic described.

The patient made an uncomplicated recovery, and when he was last seen, on April 2, 1948, his vision was 20/20 with correction in each eye and both eyes were quiet (fig. 13).

Case 4.—Master J. K., aged 2, was seen by Dr. J. H. Dunnington on May 7, 1948, because of ptosis of the left upper lid since birth. Examination showed bilateral ptosis, greater in the left eye, the fissures with the eyes in the primary position, measuring 7 mm. in the right eye and 4 mm. in the left eye. Extraocular muscle movements seemed normal.

On June 16 the left superior rectus was shortened 8 mm. and, after division of the muscle tongue into three smaller tongues, the latter were carried forward

into the upper lid and tied so that the margin of the upper lid was at the upper portion of the limbus.

The dressing was changed on the fourth day. Faint staining of the cornea was noted the next day but cleared up promptly with the use of methyl cellulose three times a day.

CASE 5.—Miss C. A., aged 16, came to the Vanderbilt Clinic on Dec. 10, 1943, because of drooping of the upper lid of the left eye since birth. Examination showed vision to be 20/30 in the right eye and 20/70 in the left eye, without correction. There was present ptosis of the left upper lid of 5 to 6 mm. in looking up, 4 to 5 mm. in looking straight ahead and none in looking down. No gross imbalance of the extraocular muscles was noted, and the fundi were normal. Questionable levator action was present; so on December 16, a resection

Fig. 14 (case 5).—Ptosis of the left eye with a weak superior rectus muscle. Note the corrugation of the forehead in *A* and *B* and the left hypotropia in *B* in looking up before operation. After operation, the action of the frontalis muscle is absent; the ptosis is well corrected, a good upper lid fold is present, but some hypotropia of the left eye persists in looking up. *A* is to be compared with *C* and *B* with *D*.

of the levator muscle was attempted but abandoned because no true levator tissue was found. Instead, a Wheeler orbicularis transplantation for ptosis was done. The patient made an uneventful recovery, with improvement of 2 mm. in the ptosis, but definite weakness of the left superior rectus muscle developed after the operation.

On Dec. 1, 1944, one year after the operation, the ptosis measured 2 mm. with eyes directed up, 2 mm. with eyes in the primary position and zero with the eyes looking down (fig. 14). At this time a second operation was done to correct the residual ptosis and the weakness of the superior rectus muscle by

shortening the latter 7 mm. and carrying the tongue of the muscle into the tissues of the upper lid, according to the technic previously described. The cornea was covered by means of a Frost suture. The patient made an uneventful postoperative recovery, and when last seen, on Dec. 27, 1946, two years after the operation, she had no complaints and the ptosis was well corrected. At no time since the operation has the patient complained of ocular discomfort, nor has staining of the cornea been present, even though the left eye is partly open during sleep. Residual weakness of the left superior rectus is still present, especially in looking upward (fig. 14), but diplopia has never been present.

Comment.—The weakness of the superior rectus was not demonstrable until after the Wheeler orbicularis operation for ptosis had been done, indicating that suspension of the upper lid from a normal superior rectus tends to weaken the lifting power of this muscle. Therefore it is only reasonable to foresee this induced weakness when utilizing the superior rectus to support the lid and to shorten the muscle at the time of operation, thus increasing its lifting power and preventing or reducing to a minimum postoperative hypotropia and diplopia.

Fig. 15 (case 6).—Complete ptosis of the right upper lid with weakness of the right superior rectus before operation. After operation, the ptosis was well corrected, and a natural-appearing upper lid fold was produced.

CASE 6.—Master J. M., aged 15, came to the Vanderbilt Clinic on Aug. 2, 1945, complaining of ptosis of the right eye, which had been present since birth. He stated that when he was 5 years of age an operation to raise the upper lid had been performed elsewhere. Examination showed his vision to be 20/50 in the right eye and in the left eye, 20/30 + 3 correctable to 20/20 in the right eye and 20/20 + in the left eye. The ptosis of the right eye measured 7.5 mm. with eyes directed up, 5.5 with eyes directed straight ahead and zero with eyes directed down (fig. 15). Examination of the extraocular muscles showed slight weakness of the right superior rectus, moderate weakness of the right inferior rectus and some weakness of the right inferior oblique. An exotropia of 6 to 11 △ suggested an incomplete paralysis of the third cranial nerve, but no definite weakness of the right internal rectus was demonstrable. The right external rectus and the right superior oblique muscle seemed normal. Levator action was entirely absent. Measurement of the fields for diplopia showed left hypertropia with eyes directed up and right and with eyes up and left but right hypertropia with eyes directed down and to the right, indicating weakness of the right superior rectus, the right inferior oblique and the right inferior rectus muscle.

On Sept. 18, 1945 a modified Motais operation was done in which the superior rectus was shortened 6 to 8 mm., according to the technic described. A Frost suture was inserted into the lower lid to cover the cornea for four days. The patient made an uneventful postoperative recovery (fig. 15). At no time since the operation has the cornea stained with fluorescein, nor has the patient complained of diplopia or of irritation, even though his right eye does not close completely during sleep.

Comment.—This patient had either a paresis of the third nerve with involvement of the superior rectus, the inferior rectus, the inferior oblique and the levator muscle or an aplasia of the extraocular muscles due to faulty embryonic development. In such a case one cannot hope

Fig. 16 (case 7).—(*A*) Complete ptosis with weakness of the superior rectus in each eye. (*B*) After operation the ptosis was well corrected, a normal curve of the upper lid was produced and a natural-appearing upper lid fold was present. No diplopia or staining of cornea has ever been present. (*C*) Note that the patient can close her eyes after the operation.

to restore normal extraocular motility. All one can reasonably hope to accomplish is to improve the cosmetic appearance in the primary position.

Case 7.—J. B., a girl aged 4 years, was brought to me because of drooping upper eyelids since birth. In order to see straight ahead, she had to raise her chin to the horizontal plane. She was mentally retarded and had six toes on the right food (two webbed and two stumps) and two webbed toes on the left foot. No one in the immediate family had ptosis or other anatomic abnormalities. Examination showed no central fixation in either eye, complete ptosis of each upper lid with no levator action, and to and fro mixed nystagmus, esotropia

of 30 △ and definite limitation of ocular elevation in each eye. In addition, she had bilateral hyaloid arteries with retrolental fibroplasia and retinal folds.

In October 1945 each superior rectus was shortened 6 mm. and the resected tongue of the superior rectus muscle carried forward into the upper lid to correct the ptosis, according to the technic described. The patient made an uncomplicated recovery and one year and three months after the operation presented the appearance shown in figure 16. At no time have the eyes watered or become red, even though both eyes remain open during sleep.

When she was last seen, in June 1948, two and one-half years after the operation, both eyes were quiet, the ptosis remained slightly overcorrected and there was still present a slow to and fro nystagmus. Most of the time her eyes were roughly straight, but at times they were crossed. Ocular elevation was improved, but remained limited in each eye.

Comment.—The ptosis in this case was intentionally overcorrected at the time of the operation, under the impression that it was necessary to do so in order to get adequate postoperative correction. In later cases the upper lid was not raised beyond the upper portion of the limbus. As a general rule the upper lid does not need to be overcorrected more than 1 or 2 mm. at the time of operation unless it is unusually heavy and thick. Most normal upper lids overlap the upper limbus 2 to 3 mm., so that if the upper lid is placed at the upper limbus at the close of the operation, the lid will "fall" this amount by the time the first dressing is done, four or five days after the operation. This falling of the lid is thought to be due to postoperative edema, stretching of the tongues of the superior rectus muscle, pulling out of the sutures or contraction of the orbicularis muscle.

Case 8.—Miss M. K., aged 20, came to the Vanderbilt Clinic on Oct. 19, 1945, complaining of ptosis of the right eye, which had been present since birth. She stated that from 1940 to 1944 the right eye had been operated on elsewhere three times for ptosis and exotropia. Examination showed complete ptosis of the right eye, a scar in the right upper lid (probably from a frontalis muscle operation for ptosis) and scar tissue in the conjunctiva over the internal and external rectus muscles. There was complete paralysis of all the extraocular muscles innervated by the third nerve, and the right pupil was fixed and smaller than the left. Vision was 20/30 in the right eye and 20/20—3 in the left eye, and both fundi were normal.

On Nov. 6, 1945 the right inferior rectus was recessed 5 mm., the right superior oblique tenectomized 4 mm., the right superior rectus shortened 5 mm. and the tongue of the superior rectus muscle carried forward into the upper lid, according to the technic described. At the conclusion of the operation the cornea was covered by means of a Frost suture through the lower lid.

The postoperative course was uneventful except for moderate epiphora of the right eye and faint stippled staining of the corneal epithelium with fluorescein for three or four weeks after operation. When she was last seen, on April 25, 1947, seventeen months after the operation, there was no staining of the cornea, and the patient was pleased with her appearance, although the palpebral fissure of the right eye remained 1 mm. narrower than that of the left eye and movement of the right eye was greatly limited in all directions of gaze.

Comment.—Patients with complete paralysis of the third nerve present a difficult cosmetic and functional problem, because not only must the ptosis be corrected but the heterotropia must also be remedied. Even after the ocular deviation and the ptosis have been corrected, the patient has little control of the eye because of the multiple extraocular muscle paralyses. Even though this operation for ptosis leaves much to be desired in cases of this condition, it gives a better cosmetic and functional result than any other operation for ptosis I know of.

CASE 9.—On Oct. 18, 1940 Master A. F., aged 9 months, was first brought to the Vanderbilt Clinic because of drooping of the left upper lid since birth. In March 1942, when he was 2 years old, the ptosis measured 7 mm. with eyes directed up, 6 mm. with eyes directed straight ahead and zero with eyes down. The extraocular muscles were normal.

On March 10, 1942 a Young operation for ptosis was done on the left eye, with little or no improvement in the ptosis; so on April 13, 1943 a Motais-Kirby operation was performed. After this the ptosis was greatly improved, but weakness of the left superior rectus developed, which produced right hypertropia of 40 △ with eyes directed up and to the left. To correct the hypertropia and the 1 mm. of remaining ptosis, the left superior rectus was shortened 5 mm. and the tongue of the superior rectus muscle carried forward into the upper lid on Jan. 10, 1946. Eight days after the operation the patient returned to the clinic with an area of superficial staining of the cornea directly under the left upper lid, which disappeared in a few days with the use of methyl cellulose.

When last seen, in July 1948, two and one-half years after the last operation, the patient was comfortable, and the cosmetic result was good. However, some weakness of the levators of the left eye persisted, producing a right hypertropia of 14 △ in the primary position.

Comment.—In this case, as in case 1, weakness of the superior rectus muscle developed after the Kirby-Motais operation for correction of the ptosis. In another survey [1] on the results of operations for ptosis of this type, it was shown that in 74 per cent of cases postoperative weakness of the superior rectus developed. Therefore it would seem wise to shorten the superior rectus, even when normal, whenever one is doing a Motais operation in order to prevent or to reduce to a minimum postoperative hypotropia and diplopia.

CASE 10.—Miss C. B., aged 9 years, had had complete ptosis of the left eyelid since birth, for which two frontalis muscle operations had been done elsewhere, without improvement. Examination showed vision of 20/20 in the right eye and 20/70 in the left eye, unimproved by glasses. There were complete ptosis of the left eye, two scars in the skin of the left upper lid, some misdirected cilia (presumably from the two previous operations) and left hypertropia of 10 △ in the primary position, which increased to 40 △ with eyes directed up and to the left. A diagnosis was made of complete ptosis of the left eye with complete paralysis of the left superior rectus muscle.

In April 1946 the left superior rectus was shortened 8 to 10 mm., the left inferior rectus recessed 5 mm. and the left superior oblique tenectomized 5 mm.

At the same time, the muscle tongue from the superior rectus was carried forward into the upper lid to elevate it to the upper border of the pupil, thus matching the upper lid of the opposite eye.

When the dressing was removed five days later, the sutures in the skin of the upper lid had sloughed out, and some pus was present in the wound. One week later the infection had cleared up. The visual axis of the left eye was then horizontal and parallel with that of the right eye in the primary position. However, upward elevation remained limited in the field of action of the left superior rectus. When the patient was last seen, in September 1946, five months after the operation, the ptosis was well corrected, the weakness of the left superior rectus persisted, but the general appearance was greatly improved. However, the scars in the skin of the upper lid and the misdirected cilia remained.

Comment.—Complete ptosis with complete paralysis of the superior rectus is one of the most difficult types of ptosis to correct. No matter what operation is done, a perfect cosmetic and functional result is impossible. The most one can hope for is to correct the ptosis and the hypotropia, so that the cosmetic result will match the fellow eye in the primary position.

Case 11.—Master G. Y., aged 5 years, came to the Vanderbilt Clinic on Nov. 18, 1946, because of drooping of the left upper lid since birth. Examination showed bilateral ptosis—greater on the left side—associated with esotropia of 30 △ and severe weakness of the left superior rectus muscle.

On Nov. 21, 1946 the left inferior rectus was recessed 5 mm., the left superior rectus muscle was shortened 8 mm. and the resected tongue from the superior rectus was carried forward into the upper lid to correct the ptosis.

The child made an uneventful postoperative recovery, and when he was last seen, on July 14, 1947, six months after the operation, the cosmetic result from the operation was good. However, a moderate amount of left hypotropia persisted. At no time did the patient have any trouble from exposure of the cornea, even though the patient left for his home, hundreds of miles away, shortly after the operation and was not seen again in the clinic for six months.

Comment.—In cases in which the superior rectus is paralyzed or very weak, it is not enough to shorten this muscle. To correct the hypotropia adequately, it is necessary also to recess the inferior rectus at least 5 mm. If this is not done, the ptosis only will be corrected and the hypotropia will remain. If the inferior oblique also is weak, then the relative lifting power of this muscle can be increased by tenectomizing the direct antagonist, the homolateral superior oblique muscle. This is easily accomplished at the time of shortening the superior rectus because the reflected tendon of the superior oblique lies directly under the tendon of the superior rectus muscle.

Case 12.—Mr. J. R., a chauffeur aged 46, was seen in the ophthalmologic department of the Vanderbilt Clinic on April 18, 1947, with ptosis of the right upper lid. He stated that his ptosis first developed in 1935, three weeks after an injury to the right upper lid. In August 1941 the right levator muscle had been resected, and in November of the same year a Motais operation had been done. After the last operation diplopia was present in looking straight ahead in the

horizontal plane unless he raised his chin. Examination of his eyes in April 1947 showed vision 20/20 in each eye without correction and marked ptosis of the right upper lid, associated with right hypotropia of 12 △ in the primary position, which increased to 35 △ in the field of action of the right superior rectus.

On May 6, 1947 the right superior rectus was shortened 10 mm. and the muscle stump carried forward into the upper lid, so that the margin of the upper lid was level with the upper portion of the limbus at the close of the operation. After removal of the Frost suture on the fifth postoperative day, a small area of staining of the cornea developed within the first twenty-four hours; this soon cleared with use of methyl cellulose. Six weeks after the operation, no diplopia was present with the eyes in the primary position, the cornea did not stain and the ptosis was well corrected except for slight sagging of the lateral third of the upper lid.

Comment.—When using this operation for adults, one must guard against lesions of the cornea for weeks after operation, for the corneal epithelium of an adult takes longer to adjust itself to exposure to the air than that of a child. This is to be expected, because the tissues of children are more adaptable than those of adults and because it is unreasonable to expect a corneal epithelium which has been covered by the upper lid for twenty or thirty years to adjust itself within a few days to drying in the air. In some adults it may be necessary to cover the exposed cornea by pulling the lower lid up over the cornea at night by means of a strip of adhesive plaster attached to the cheek and anchored to the skin of the brow. If this regimen is followed at night and methyl cellulose used three or four times in the daytime, the corneal epithelium will adjust itself in a few weeks to the new conditions forced on it.

Case 13.—R. W., a youth aged 16, consulted Dr. A. B. Reese with exophthalmos of the right eye. A Krönlein operation, done by Dr. Reese, exposed an extensive pseudotumor within the muscle cone, which was adherent to all the retrobulbar tissues and was removed with difficulty. After this operation, the patient's vision improved from 15/200 to 20/40, and a previously existing papilledema of 6 D. completely subsided. However, paralysis of ocular elevation with ptosis developed. An operation was done on June 30, 1947 by Dr. Reese to elevate the globe and to correct the ptosis by shortening the superior rectus muscle 8 mm. and by transplanting and anchoring the resected tongue to the tissues of the upper lid, according to the technic aforedescribed. After the operation, considerable edema of the upper lid and a small area of superficial staining of the cornea developed. Both these conditions soon disappeared, and when the patient was last seen, in February 1948, eight months after operation for ptosis, vision in the left eye had improved to 20/25, with correction. The ptosis was improved, but there was little movement of the globe in looking up. Obviously, the nerve supply to the superior rectus and the levator had been injured during the Krönlein operation.

Case 14.—Miss J. L., aged 35, came to the Vanderbilt Clinic with congenital ptosis of the left eye. Three operations for ptosis had been done on this eye twenty-seven, twenty-five and twenty-one years before, respectively, with slight improvement after each operation. Examination showed 5 mm. of ptosis (fig. 17) of the left upper lid with pronounced left hypotropia of 45 △ in the primary position, associated with complete paralysis of the left superior rectus. There

remained only 3 mm. of the upper tarsus of the left eye, indicating that she had had one or more resections of the tarsus and/or the levator muscle.

On July 2, 1948 the inferior rectus was recessed 6 mm., the superior rectus shortened 10 mm. and the ptosis corrected by carrying the tongue from the superior rectus into the tissues of the upper lid. At the same time the superior oblique was tenectomized under the superior rectus to increase the relative lifting power of the left inferior oblique. A Frost suture was inserted into the lower lid to cover the cornea, and a pressure dressing was applied. The dressing and the Frost suture were removed on the fourth postoperative day and the eye left uncovered. There was slight staining of the cornea at times for the first three weeks, but when the patient was last seen, on August 6, one month after operation, there was no more staining. The ptosis was well corrected, and the hypotropia was improved (fig. 17).

Case 15.—Master L. K., aged 1½ years, was seen in the ophthalmology department of the Vanderbilt Clinic on Dec. 14, 1945 because of ptosis of the right eye. A Dickey operation for ptosis with use of preserved fascia lata had been done two and one-half months before. Examination was essentially noncontributory except for complete ptosis of the right eye associated with paralysis of ocular elevation and the jaw-winking phenomenon of Marcus Gunn. The right

A B

Fig. 17 (case 14).—(*A*) Complete ptosis of the left upper lid with paralysis of the left superior rectus muscle. Three operations for ptosis had been done on this eye, leaving very little tarsus. (*B*) Note that the ptosis is well corrected and that some hypotropia of the left eye remains. The sagging of the upper lid to either side of center is due, at least in part, to partial absence of the tarsus.

eye showed 30 △ of hypotropia in the primary position, and the complete ptosis of the right eye was decreased intermittently about 50 per cent by chewing gum.

On April 14, 1947, with the child under general anesthesia, a traction test on the inferior rectus, made by passing a muscle hook under it and exerting traction forward, showed that the muscle was nonelastic. This muscle was thought to be fibrotic and was therefore recessed 6 mm. At the same time the superior oblique was tenectomized 5 mm. under the superior rectus, the superior rectus was shortened 6 to 8 mm., and the muscle tongue from the latter carried forward into the tissues of the upper lid and tied to bring the upper lid even with the upper portion of the limbus. The cornea was covered by means of a Frost suture in the lower lid.

After removal of the dressing on the fourth day, there was faint superficial staining of the cornea for seven days. This condition was favored by the fixed position of the right eye in looking up or down, which was due to the fibrotic, nonelastic inferior rectus. The ptosis was well corrected; the jaw-winking reflex was cured; the hypotropia was greatly reduced, and the patient could close his right eye voluntarily. One month later, when the child was seen at the clinic, the eyes were white and there was no staining of the cornea or tearing.

On Nov. 11, 1947 the mother stated that the child slept with the right eye open but that there was no discomfort, tearing or staining. On May 9, 1948 the patient came to the clinic with a foreign body embedded in the cornea over the pupillary area. On May 11 the eye was white.

CASE 16.—Master A. K., aged 4, came to the Vanderbilt Clinic with a history of ptosis of the left upper lid since birth. Examination showed incomplete ptosis of the left eye associated with the jaw-winking phenomenon of Marcus Gunn and with definite weakness of the left superior rectus muscle.

On May 27, 1948 the right superior rectus was shortened 8 mm.; the aponeurosis of the levator muscle was excised for a width of 4 to 5 mm. over the anterior surface of the tarsus, and the muscle tongue from the superior rectus was carried forward into the upper lid and tied, so that the upper lid overlapped the cornea about 1 mm. The dressing was removed on the fifth postoperative day, and the patient was discharged on the eighth postoperative day, with instructions to his parents to use methyl cellulose three times a day and at bedtime.

When seen in the clinic two months after the operation, there was residual left hypotropia, a good upper lid fold and no jaw-winking reflex. When the patient looked downward about 20 degrees below the horizontal plane, the cosmetic appearance was excellent; the visual axes of the eyes were parallel, and the upper lids matched well as to position, contour and presence of the upper lid folds.

CASE 17.—Master I. S., aged 7, consulted Dr. A. B. Reese in October 1945 with a history of ptosis of the right upper lid since birth. Examination showed vision of 20/70 in the right eye and 20/15, uncorrected, in the left eye, 4 mm. of ptosis of the right upper lid, paralysis of the right superior rectus and the jaw-winking phenomenon of Marcus Gunn. On November 23, the right superior rectus was shortened 6 mm. by Dr. Reese, and the muscle tongue was carried forward and anchored to the tarsus of the upper lid. The cornea was covered by pulling the lower lid upward by means of a Frost suture.

When the child was last seen, in January 1946, six weeks after the operation, 1 mm. of ptosis remained, but the jaw-winking reflex was cured and the upper lid moved synchronously up and down with the globe.

Comment.—At least 75 per cent of patients with the jaw-winking phenomenon of Marcus Gunn have weak superior rectus muscles associated with the ptosis. Cases of this kind present a problem, because not only the ptosis but the jaw-winking phenomenon and the hypotropia must be corrected. These three objectives can be accomplished by the operation described here if, at the same time, the aponeurosis of the levator muscle is excised for 5 to 6 mm. anterior to the tarsus.

CASE 18.—Miss K. C., aged 12, was seen in the Vanderbilt Clinic on Jan. 6, 1947 because of a residual ptosis of the left eye. She stated that she had been born with a drooping left upper lid, which moved up and down when she chewed. In January 1940, when 5 years old, a Wheeler orbicularis operation had been done to correct the ptosis. At the same time a portion of the levator tendon had been excised anterior to the tarsus to destroy the action of the levator and correct the jaw-winking phenomenon. After this, the jaw-winking phenomenon disappeared, but some ptosis remained, so that in July 1942 a partial tarsectomy was done.

Examination in January 1947 showed vision of 20/30 in the right eye and 20/40, uncorrected, in the left eye. The left eye was directed downward and

outward, producing exotropia of 24 △ and right hypertropia of 42 △ in the primary position. One or 2 mm. ptosis remained, but the jaw-winking phenomenon was not present.

On January 22, the inferior rectus muscle was recessed 5 mm., the superior rectus was shortened 6 to 8 mm. and the tongue of the superior rectus muscle carried forward into the upper lid to correct the remaining ptosis.

On the fifth day after this operation the upper lid became infected and pus exuded from the wound. The swelling and infection subsided in one week, leaving a scar of the upper lid. Six months after the last operation 30 △ of left hypotropia was still present, but the ptosis was overcorrected 1 mm. with regard to the upper limbus of the left eye. This overcorrection was attributed to contraction of scar tissue following the infection of the upper lid. (At the conclusion of the operation the upper lid overlapped the upper portion of the limbus 1 to 2 mm.)[9] At no time since the operation has corneal staining developed, despite the fact that the upper lid does not cover the cornea in sleep.

Comment.—It is difficult to evaluate the final result in this case because the patient had had two previous operations for ptosis and because the infection in the upper lid following the last operation had an unknown effect on the final result. This patient had been treated for two weeks prior to operation with penicillin ointment because of a sty of the left upper lid, and it may be that some of the organisms were still present at the time of the last operation.

Case 19.—Miss C. C., aged 15, came to Dr. J. H. Dunnington in July 1948 with complete ptosis of the left eye associated with the jaw-winking phenomenon. Eleven years before, the left superior rectus had been resected, the left inferior oblique advanced and the left levator resected. On examination in July 1948 the left eye was in good position, but the patient was unable to elevate it. Besides, there was almost complete ptosis associated with the jaw-winking phenomenon.

On July 21, 1948 a nonelastic left inferior rectus was recessed 3 mm., the left superior rectus shortened 7 mm. and the ptosis corrected by the method described here. At the close of the operation the upper lid was 2 mm. above the limbus. A Frost suture was inserted into the lower lid and the latter pulled up to cover the cornea. A pressure dressing was applied for four days. When last seen, ten days after the operation, the ptosis was improved and the patient returned to her home in Georgia and has not been seen since.

Case 20.—R. C., a girl aged 4, came to the ophthalmology department of the Vanderbilt Clinic on June 14, 1946 with bilateral congenital ptosis. There was no history of congenital ptosis in the immediate family, but the father had what the mother described as a "wide nose," simulating that of the patient (fig. 18). Examination showed complete ptosis of both eyes, blepharophimosis of each eye and an abnormally wide space between the inner canthi over the bridge of the nose. Each fissure measured 13 mm. in length, and the distance from one inner canthus to the other was 45 mm. (fig. 18). Both globes and the extraocular movements seemed normal.

9. This is the only case in which the upper lid took a position after operation higher than that at which it had been placed at the time of operation. Usually it is necessary to place the upper lid 1 or 2 mm. above where one hopes to find it when healing is complete.

On August 15, the internal canthal ligaments were advanced 4 to 5 mm. over the bridge of the nose and the external canthal ligaments severed to allow the fissures to be moved nasally. This shortened the distance between the inner canthi from 45 to 38 mm. and lengthened the fissures from 13 to 15 mm.

On October 24, the right fissure was further lengthened by means of an external canthoplasty, the superior rectus shortened 8 mm. and the tongue of the superior rectus muscle carried forward into the tissues of the upper lid according to the technic described here. On Jan. 16, 1947 an exactly similar procedure was done on the left eye. These operations widened and lengthened the fissures several millimeters (fig. 18).

After each of these operations the patient made an uneventful recovery. Faint staining of each cornea was noted for a few days immediately after each of the two last operations; this disappeared with use of liquid petrolatum several times during the day and at bedtime.

Comment.—This patient requires another operation to shorten the distance between the inner canthi and to lengthen the fissures, which are so far displaced laterally that it is impossible for her to see simultaneously with both eyes when looking to the right or to the left.

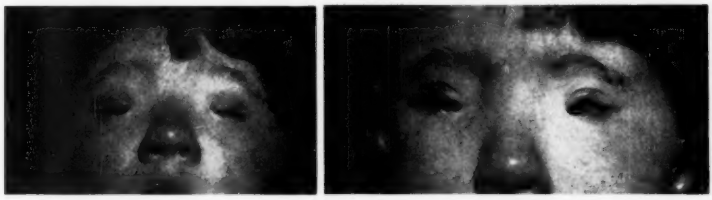

Fig. 18 (case 20).—Complete ptosis with blepharophimosis. Note the great distance between the inner canthi and the S-shaped deformity of the palpebral fissures and lower lids. After operation, the ptosis is less; upper lid folds are present, and the patient can see straight ahead without raising her chin.

At a later date a piece of cartilage will be inserted over the bridge of the nose under the skin to bring the inner canthi toward the midline. This should improve her appearance greatly.

Ptosis of this nature is among the most difficult to correct and requires patience and ingenuity to secure any cosmetic or functional improvement.

SUMMARY

More than eighty operations for ptosis have been described, none of which is entirely satisfacory in all cases. Especially difficult are cases in which resection of the levator is contraindicated. In these cases, suspension of the upper lid from the superior rectus by the operation described here is recommended, for several reasons:

1. The superior rectus can be used even though paralyzed.

2. Slipping of the transplanted superior rectus tongue is reduced to a minimum.

3. A smooth upper lid curve results.
4. Entropion, or inturning of the lashes, is prevented.
5. A natural-appearing upper lid fold is produced.
6. Postoperative hypotropia is prevented or reduced.
7. The operation can be done on very young children.
8. The upper lid moves up and down synchronously with the globe.
9. The operation is not difficult.

The only disadvantages of the operation are that normal winking is interfered with and lagophthalmos during sleep occurs. The former is scarcely noticed by the laity, and the latter is no problem because the patient, in some cases, learns to protect his cornea from exposure by turning it to the side under the external canthus when closing his eyes, while in other cases the epithelium of the cornea seems to adapt itself to the exposure.

The operation is modeled more or less after the Motais procedure. It consists in shortening the superior rectus 5 to 10 mm. (depending on the amount of weakness of this muscle) and suturing the resected portion or tongue of this muscle to the tissues of the upper lid.

This operation has been done in 20 cases without failure in any case. In 4 cases in which the superior rectus was normal, no overaction of this muscle was demonstrable after operation, even though the superior rectus was shortened 5 to 6 mm. In 10 cases in which the superior rectus was weak the ptosis and the hypotropia were corrected or reduced. In 5 cases of ptosis associated with the jaw-winking phenomenon both conditions were corrected. In 1 case of ptosis associated with blepharophimosis the ptosis and blepharophimosis were improved.

CONCLUSIONS

An operation utilizing the superior rectus muscle which is designed to prevent hypotropia and correct ptosis is presented.

The operation has been used in 20 cases without a single failure.

It is recommended only when resection of the levator is contraindicated, for example in cases of (*a*) complete ptosis with a normal superior rectus muscle; (*b*) complete ptosis with a weak superior rectus muscle; (*c*) ptosis associated with the jaw-winking phenomenon of Marcus Gunn, and (*d*) complete ptosis associated with blepharophimosis.

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OCULAR EFFECTS OF THE CHOLINE ESTERS

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THE OCULAR effects of choline and its derivatives are receiving increased attention not only as important metabolic and physiologic factors but also as therapeutic agents. Until recently use of these compounds in ophthalmology was limited largely to the miotic treatment of glaucoma; however, synthesis by Swan and White [1] of choline esters with mydriatic and cycloplegic properties has greatly increased the possible therapeutic applications of the group. The ocular effects of the first choline to be known have not been fully investigated, nor have the possibilities for synthesis of new and more effective derivatives been fully exhausted; however, there are sufficient experimental data to provide a scientific basis for the clinical application of most of the presently known derivatives. These data are important to ophthalmologists, for, as compared with the commonly used drugs of the alkaloid series, the choline derivatives are unique in their chemical, physical and pharmacologic properties.

Some knowledge of the chemistry of choline is essential to proper application of choline and its esters in ophthalmology. Choline contains a quaternary ammonium group, that is, four methyl groups attached to a nitrogen molecule. In biochemistry and physiology the quaternary ammonium group receives considerable attention as a source of "labile" methyl groups for the metabolism of other substances, but from the ophthalmologic point of view quaternary ammonium groups are important because they dominate the physical properties and thereby influence the corneal penetration and mode of administration of all choline esters. Quaternary ammonium groups have a decided affinity for water; consequently, choline and all of its commonly used esters are extremely hydrophilic (fig. 1).

When a medicament is placed in the conjunctival sac, the distribution of the drug between the drug vehicle and the tissue is generally

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1. Swan, K. C., and White, N. G.: Proc. Soc. Exper. Biol. & Med. **53**:164, 1943.

in accordance with the relative affinity of the drug for the vehicle and for the tissues.[2] It is important to apply this "law of relative affinities" to the clinical administration of such highly hydrophilic compounds as choline and its esters (fig. 2). If these drugs are administered in simple aqueous solution, they tend to be retained in the water vehicle, for which they have a high affinity, and little penetrates the corneal epithelium. It is obvious that choline esters would be most effectively administered if suspended in an anhydrous base, such as petrolatum. In these circumstances they have a relatively greater affinity for the

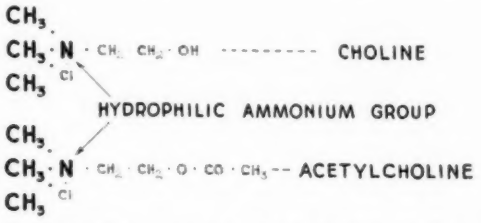

Fig. 1.—Dominant hygroscopic groups in choline and acetylcholine.

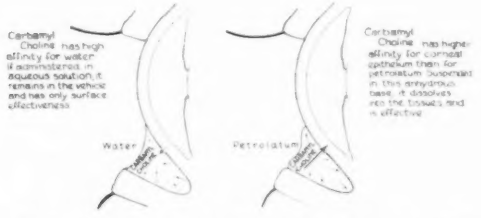
Carbamyl Choline has high affinity for water. If administered in aqueous solution, it remains in the vehicle and has only surface effectiveness
Water
Carbamyl Choline has higher affinity for corneal epithelium than for petrolatum. Suspended in this anhydrous base, it dissolves into the tissues and is effective
Petrolatum

Fig. 2.—Diagram illustrating the law of relative affinities. Distribution of a solute (drug) between two immiscible solvents, e. g., tissue and drug vehicle, is generally in accordance with the relative solubilities (affinities) of the solute in the two solvents.

precorneal film and the epithelium than they do for the vehicle and therefore penetrate the cornea with greater consistency than when instilled in simple aqueous solutions.

The effect of choline chloride on the intraocular muscles is that of a weak stimulation of the sphincter of the iris and the ciliary muscles. These stimulatory effects are greatly increased in certain of its esters. Acetylcholine, the acetic acid ester of choline, is thought to be the chemical mediator of many types of nerve impulses because transmission of

2. Swan, K. C.: Pharmacology and Toxicology of the Cornea, Arch. Ophth. **41**:253-275 (March) 1949.

the nerve impulse is associated with release of acetylcholine in the tissues. For example, stimulation of the parasympathetic fibers of the oculomotor nerve results in miosis and cyclotonia due to contraction of the sphincter of the iris and some of the ciliary muscles. This action is associated with release of acetylcholine in these tissues; conversely, acetylcholine injected into the eye simulates stimulation of the parasympathetic nerve fibers. This physiologic action of acetylcholine is terminated by an enzyme, choline esterase, which is present in the tissues, including the iris and the ciliary body. This esterase splits acetylcholine at its ester linkage and rapidly terminates its physiologic action.

Early investigators believed acetylcholine to be inactive on the intraocular muscles because they did not recognize that when instilled in aqueous solution it penetrates the epithelium poorly. Acetylcholine so administered reaches the intraocular tissues at such a slow rate that it is hydrolyzed by the esterase before its pharmacologic effects become manifest; however, even if acetylcholine is effectively administered, e. g., by iontophoresis, its ocular effects are evanescent. For this reason, acetylcholine, while of great physiologic significance, has little direct value as a therapeutic agent. Its greatest importance in ocular therapeutics lies in the enhancement of the physiologic action by drugs which inhibit the choline esterase.

A number of compounds inhibit the choline esterase and thus, by preventing hydrolysis of acetylcholine in the tissues, have an indirect stimulatory action on the iris and ciliary body. One of these drugs, physostigmine, was used clinically as a miotic in the treatment of glaucoma many years before the mechanism of its action was known. The most important component of physostigmine was discovered by Stedman and White [3] to be the urethane group. A number of simple aromatic compounds containing this group have been synthesized, all of which actively inhibit the choline esterase. Neostigmine is the best known example. Another drug with intense and prolonged inhibitory effects on the choline esterase was developed recently from the war gases. Di-isopropyl-fluorophosphate, commonly known as DFP, has the same action on intraocular muscles as physostigmine and neostigmine, but its effects are more intense and prolonged.[4]

Physostigmine, neostigmine, di-isopropyl-fluorophosphate and related compounds which enhance the physiologic action of acetylcholine are spoken of as indirect stimulatory miotics, to distinguish them from drugs like pilocarpine which directly stimulate the sphincter of the iris

3. Stedman, E., and White, A. C.: J. Pharmacol. & Exper. Therap. **41**:259, 1931.

4. Leopold, I. H., and Comroe, J. H., Jr.: Use of Diisopropyl Fluorophosphate ("DFP") in Treatment of Glaucoma, Arch. Ophth. **36**:1 (July) 1946.

and from drugs like dibenamine (dibenzyl-beta-choroethylamine) [5] which induce miosis by relaxation of the dilator of the iris. The division of stimulatory miotic drugs into direct and indirect stimulants is of clinical importance, for it largely determines their use in glaucoma (fig. 3).

As might be expected, action of the indirect stimulatory miotics on intraocular muscles simulates the sharp contraction of the iris sphincter and the ciliary muscle resulting from administration of acetylcholine. When the breakdown of acetylcholine is inhibited by these drugs, the sharp contraction is prolonged and is in effect a spasm. The spastic action of physostigmine and related drugs on the intraocular muscles is of particular value in patients with acute congestive glaucoma of the shallow chamber type. In these patients primary concern is to effect a sharp reduction in intraocular tension with a minimum of delay. Vision is so obscured from the acute glaucoma, and the patient is

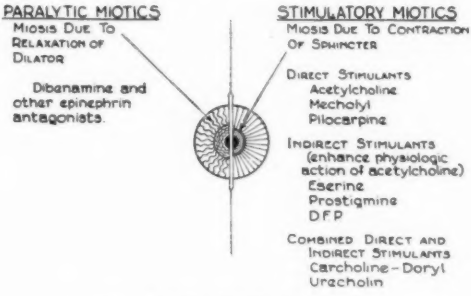

Fig. 3.—Classification of miotics.

already suffering from the pain to such an extent, that the ocular discomfort effected by the drugs is of little consequence. On the other hand, the spastic action of these drugs is a distinct disadvantage in the treatment of patients with chronic noncongestive glaucoma. The violent contraction of the iris sphincter and ciliary muscle is apt to be uncomfortable unless either the drugs are administered in small doses or the maximal effect is maintained by large doses. Also, these drugs have a more profound effect on accommodation than has pilocarpine and thereby disturb vision. In some cases this stimulation of accommodation can be maintained at a fairly constant level and the induced change in refractive error can be corrected by lenses; but in many cases of chronic noncongestive glaucoma this measure is not feasible. In young adults the variation in refractive error due to these medicaments may amount

5. Christensen, L., and Swan, K. C.: Tr. Am. Acad. Ophth., May-June 1949, pp. 489-497.

to several diopters during the day. Also, as the effects of the indirect stimulatory miotics wear off the iris sphincter and the ciliary muscles are hyperreactive and hypertonic. A hyperactive pupillary light reflex may last many days after a single administration of di-isopropyl-fluorophosphate to a normal eye, and a spasm of accommodation may result from only a short period of reading. Moreover, these effects are not limited to the intraocular muscles; e. g., an annoying twitching of the orbicularis may accompany the ocular administration of physostigmine. In contrast, the response of the pupil and the ciliary body will be decreased as the effects of pilocarpine or other direct stimulants wear off. Di-isopropyl-fluorophosphate seems the most effective agent to counteract the effects of atropine, but its use should be reserved for emergency. When it is administered routinely to counteract the effect of mydriatics and cycloplegics, the discomfort that it causes may be greater and more prolonged than the disability of mydriasis and cycloplegia. Di-isopropyl-fluorophosphate seems the drug of choice in the treatment of aphakic glaucoma. In aphakic patients this drug causes little ocular discomfort and no disturbance of vision. The glaucoma can often be controlled by only a few instillations weekly.

It has long been known that in patients who have received physostigmine over a long period not only follicular conjunctivitis but mild anterior uveitis may develop. These inflammations seem to be due to the irritating properties of the free physostigmine base. Addition of an acid buffer to the vehicle prevents the conjunctival reaction but has no influence on the intraocular irritation produced by the drug. It seems that di-isopropyl-fluorophosphate may also produce ocular inflammation. Dunphy [6] has observed cells in the aqueous of patients receiving this drug. In the University of Oregon Medical School Clinics a recurrence of the inflammatory process occurred after administration of di-isopropyl-fluorophosphate in 4 cases of chronic glaucoma developing or persisting after uveitis. In 1 of the cases there had been no active inflammation for eighteen months, and in another case the uveitis had been quiescent for six months. This number of cases is not an adequate basis on which to draw conclusions, but the occurrence indicates that di-isopropyl-fluorophosphate should be used with caution in cases of postinflammatory glaucoma.

When it became apparent that the choline inhibitors were not ideal drugs for the treatment of chronic noncongestive glaucoma, attention of ophthalmic pharmacologists turned to those choline derivatives which had more prolonged pharmacologic effects than acetylcholine. A number of choline esters have been synthesized with greater stability in the tissues than acetylcholine but with the same direct stimulatory effects on

6. Dunphy, E.: Personal communication to the author.

the intraocular muscles. The onset of their action is more insidious, less spastic and more easily controlled than that of acetylcholine and the previously discussed indirect stimulants. As the effects of these choline esters wear off, the tonus and the reactivity of the iris sphincter and ciliary muscle are reduced, whereas, as previously stated, a hyperreactivity follows use of the indirect stimulants, such as physostigmine and di-isopropyl-fluorophosphate.

Substitution of a methyl group for one of the hydrogen molecules in the beta position increases considerably the stability of acetylcholine in the tissues. This synthetic compound, methacholine chloride U. S. P. (acetyl-beta-methylcholine chloride; mecholyl® chloride), is a highly specific stimulant of parasympathetic structures, including the iris sphincter and ciliary muscles. Methacholine has longer action than acetylcholine but is a short-acting drug. Its maximal effects on the intraocular muscles following instillations into the conjunctival sac last less than an hour. The stimulatory effects of methacholine may wear off completely in several hours and are often followed by a short period of decreased reactivity of the intraocular muscles.

When administered in simple aqueous solution, methacholine, like acetylcholine, penetrates the normal corneal epithelium poorly; consequently, its effects are inconsistent unless precautions are taken to insure its absorption. Disturbance of the corneal epithelium by physical or chemical means greatly increases the penetration of the methacholine. Therefore, a practical method of administering the drug is to precede it with instillation of a topical anesthetic which disturbs the corneal epithelium, for example, 0.5 per cent tetracaine hydrochloride. When this procedure is followed, a single drop of 5 or 10 per cent methacholine chloride consistently produces miosis and cyclotonia; however, the most effective method of rapidly administering the drug is by iontophoresis. Intense miosis with a minimum of systemic effects can often be effected in a matter of minutes.

The action of the methacholine is so short that its use is largely limited to the treatment of acute congestive glaucoma of the shallow chamber type. The administration of methacholine by iontophoresis seems superior to instillations of the drug or of physostigmine. In some patients a drastic drop in tension has been observed to occur within thirty minutes, in contrast to the several hours which are required to bring down the tension when physostigmine is administered by instillation or in an ointment. A patient with acute congestive glaucoma is a true emergency, in which every minute is important in the preservation of vision.

Methacholine, administered by iontophoresis, fills an important need in the treatment of acute glaucoma, but if the apparatus is not available the drug can be administered by instillation. Methacholine solution is

usually well absorbed in eyes with this type of glaucoma, as the corneal epithelium is seldom normal and is further disturbed by the topical anesthesia and trauma associated with instrumental tonometry. Ten per cent methacholine chloride in aqueous solution has not proved more effective than physostigmine in controlling the tension; however, if repeated instillations are required, the patient has a less severe systemic reaction. Physostigmine acts over a period of hours; consequently, its systemic effects become accumulative with successive doses at short intervals. Nausea, diarrhea, pallor, weakness, sweating, salivation and a drop in blood pressure are common signs and symptoms. In contrast, tissue choline esterases terminate the action of methacholine so rapidly that the systemic effects following repeated instillations seldom become summated. This is not to imply that methacholine is not capable of serious systemic reaction. If the drug is administered at too frequent intervals and the epithelial barrier of the conjunctiva and cornea has been reduced by topical anesthesia or trauma, the drug may produce an alarming drop in blood pressure.

Clarke [7] advocated the use of methacholine and neostigmine together for their combined direct and indirect action. This combination is more potent than either of the two drugs used alone; however, in my experience their combined use has seldom been effective when methacholine, administered by iontophoresis, has failed in treatment of acute congestive glaucoma. This result is explained by histologic examination of glaucomatous eyes which have been enucleated because of the failure of therapy. The necrosis of the iris sphincter which occurs in cases of uncontrolled acute glaucoma (fig. 4) suggests that when the muscles are still reactive either of the drugs used alone is sufficiently potent, but when the muscles are severely damaged any combination is ineffective. Also, combination of the two drugs seems to increase their undesirable systemic reactions, notably gastrointestinal disturbances and lowering of the blood pressure.

Carbachol U. S. P. (carbaminoylcholine chloride; carcholin®; doryl®) was synthesized in Germany in 1931. This urethane ester of choline has much greater tissue stability than either acetylcholine or methacholine, its beta methyl derivative. Carbachol has some direct stimulatory action, and its urethane group inhibits the choline esterase; consequently, the drug is both a direct and an indirect stimulatory miotic with prolonged pharmacologic effects. It was first used in 1932 in the treatment of chronic noncongestive glaucoma by Velhagen [8]; but it was not recognized that the compound penetrated the normal cornea poorly when administered in simple aqueous solution.[9] Failure to

7. Clarke, S. T.: Am. J. Ophth. **22**:249, 1939.
8. Velhagen, K., Jr.: Klin. Monatsbl. f. Augenh. **92**:472, 1934.
9. Swan, K. C.: Journal-Lancet **57**:79, 1942.

recognize this fact led to a confusion of reports on the duration and intensity of action of the drug on the intraocular muscles; consequently, its use did not become widespread.

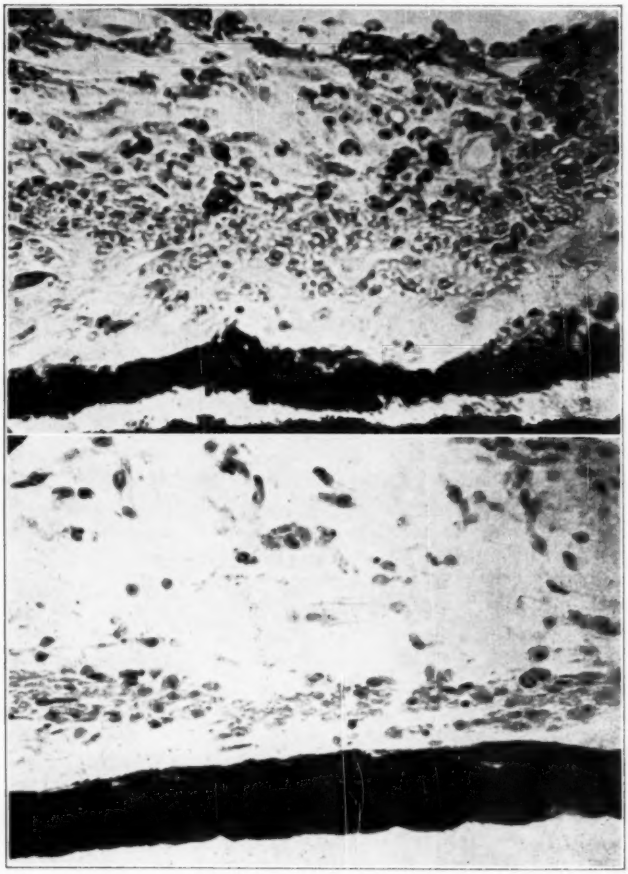

Fig. 4.—Necrosis of the sphincter of the iris of an eye with acute glaucoma (above) and the normal sphincter of an unaffected eye (below).

In 1940 Swan,[9] taking precautions to insure consistent absorption, found that the action of carbachol in cases of chronic noncongestive glaucoma was more intense and prolonged than that of equal doses of pilocarpine. With the use of carbachol in treatment of glaucoma, Swan

and O'Brien[10] introduced the use of highly surface-active (wetting) agents to increase corneal penetration of drugs. Although the value of these agents to enhance absorption of all types of ophthalmic drugs has since been confirmed by other authors, the administration of carbachol in a simple anhydrous ointment base now seems simpler and more effective than wetting agents as a means of administering this agent.[11] Carbachol, like other choline esters, has a high affinity for water; consequently, when administered in aqueous solution carbachol has a much higher affinity for the vehicle than for the corneal epithelium, and little enters the normal cornea. When administered as a dry suspension in pure petrolatum or other anhydrous base, the drug has a greater affinity for the epithelium and precorneal film than for the vehicle and therefore effectively penetrates the cornea (fig. 2). Immediate obscuration of vision by the ointment provides the patient with the assurance that the drug has definitely come into contact with the cornea. Gentle massage of the cornea through the lids further insures absorption.

Carbachol has its greatest usefulness in treatment of chronic noncongestive glaucoma. In this type of glaucoma the compound has advantages over physostigmine, neostigmine and related derivatives in that it does not produce twitching of the eyelids and has a smoother and generally more prolonged action. Although carbachol is a powerful cyclotonic drug, the refractive error may be maintained fairly constant by a regular dosage schedule.

The urethane of beta-methyl choline chloride (carbaminoyl-beta-methylcholine chloride; urecholine®) combines the two components which make methacholine and carbachol more stable in the tissues than acetylcholine. The carbaminoylcholine group increases tissue stability by inhibiting the choline esterase, and the beta methyl group increases the stability of the ester linkage. This compound, therefore, is the most potent and the longest-acting of the miotic choline series. Its use in ophthalmology has been limited, but experience with a few patients indicates that it may be more effective than carbachol in the treatment of chronic noncongestive glaucoma. Like carbachol, it penetrates the cornea poorly, and therefore the same precautions are required to insure its absorption.

In their ocular effects and therapeutic uses, carbachol and its beta methyl derivatives are more closely comparable to pilocarpine than to other ophthalmic drugs. When precautions are taken to insure their absorption, these choline esters are more effective and need be admin-

10. Swan, K. C., and O'Brien, C. S.: Carbaminoylcholine Chloride in Treatment of Glaucoma Simplex, Arch. Ophth. **27**:253 (Feb.) 1942.

11. Swan, K. C.: Carbaminoylcholine Chloride in Petrolatum, Arch. Ophth. **30**:591 (Nov.) 1943.

istered less frequently than pilocarpine; however, it is the custom in the University of Oregon to reserve their use for patients who are sensitive to pilocarpine or in whom pilocarpine does not effectively control the glaucoma. Pilocarpine salts are cheap, and for the average case of chronic noncongestive glaucoma they can be effectively administered in simple aqueous solutions. Carbachol, on the other hand, requires special vehicles and a patient sufficiently intelligent and cooperative to take the precautions necessary for its absorption. When these precautions are taken, carbachol fills an important need for patients who have advanced glaucoma. It is often effective in eyes in which operations for glaucoma have been only partially successful.

Carbachol and urecholine® are drugs with potent effects on the autonomic nervous system and therefore are capable of producing dangerous systemic reactions when excessive doses are administered to the eye, or even when the usual dose is given if the epithelial barrier of the conjunctiva and cornea is reduced. For example, the drugs should be administered with caution if topical anesthesia has been administered and the corneal epithelium has been traumatized by instrumental tonometry. In these circumstances corneal and conjunctival penetration of carbachol is tremendously increased, and enough systemic absorption of the drug may occur to effect a decided drop in blood pressure and other symptoms due to generalized parasympathetic stimulation. The drug should be used with caution in cases of asthma, because enough systemic absorption may occur to induce a spasm of the hyperreactive bronchial muscles and precipitate an asthmatic attack. When these factors are taken into consideration, carbachol and urecholine® are safe drugs to use in treatment of chronic noncongestive glaucoma.

The most characteristic action of the aforementioned choline esters is stimulation of structures innervated by the parasympathetic nervous system, that is, miosis and spasm of accommodation. In the preparation of these compounds, emphasis was placed on the development of more stable and potent derivatives of acetylcholine. The possibility of reversing its characteristic stimulatory action did not receive consideration. Moreover, no attempts had been made to correlate the pharmacologic action and the physical properties of the choline esters prior to the investigation by Swan and White, beginning in 1939. They had observed that the choline esters as a group penetrated the corneal epithelium poorly and that this impenetrability seemed related to the hydrophilic characteristic of the molecule.[12] Also, they noted that all choline esters with miotic action had little influence on the surface tension of water, i. e., these compounds were surface inactive. With this evidence of the profound influence of physical properties on the ocular effects

12. Swan, K. C., and White, N. C.: Am. J. Ophth. **25**:1043, 1942.

of the choline esters, Swan and White set out to synthesize and study the ocular effects of choline esters with different physical properties.

A review of the literature revealed no simple choline esters in which the highly hydrophilic quaternary ammonium group had been counteracted or balanced by addition of a large hydrophobic group to the molecule. Investigation of this possibility necessitated synthesis of a new compound in which the highly water-soluble choline group was

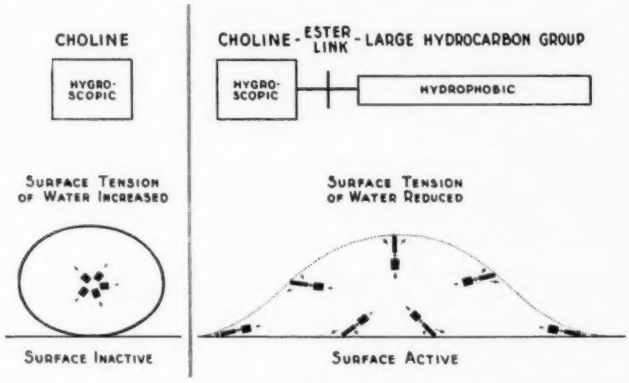

Fig. 5.—Structure and mode of action of surface-active choline esters.

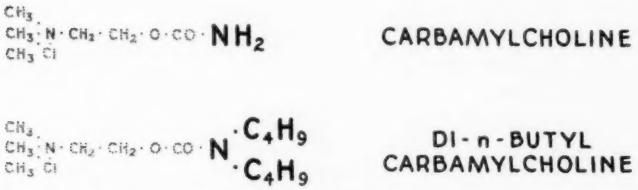

Fig. 6.—Replacement of hydrophilic NH_2 group in carbachol U. S. P. (carbaminoylcholine chloride) by a water-soluble group, dibutylamine, to form di-n-butyl-carbaminoylcholine.

combined through an ester linkage with a large water-insoluble hydrocarbon group. The resultant elongated molecules would be expected to orient themselves at the surface of aqueous solutions and thereby lower surface tension (fig. 5).

Carbachol (carbaminoylcholine chloride), most potent and stable of previously known simple choline esters, was selected for the initial conversion to a surface-active compound. The hydrophilic NH_2 group was replaced by a water-insoluble group, dibutylamine (fig. 6). The

resultant surface-active compound, di-n-butyl-carbaminoylcholine chloride, was found to have ocular effects the reverse of those of carbachol. Whereas carbachol produced miosis and spasm of accommodation, the new drug produced mydriasis and cycloplegia.[13]

A large number of compounds of this series were synthesized.[14] The mydriatic and cycloplegic actions of these choline esters seem associated with a relatively high surface activity, whereas the choline esters which have little influence on surface tension retain miotic and cyclotonic effects on the eyes. Compounds of intermediate surface activity have little pharmacologic effect.

Dibutoline sulfate (dibutylcarbamate of dimethylethyl-2-hydroxyethyl ammonium sulfate) is the most effective of the new compounds (fig. 7). It induces mydriasis by inhibition of the iris sphincter and recession of the near point of accommodation due to paresis of accommodation. The smooth muscles of the lids and the dilators of the iris, innervated by the sympathetic nervous system, are unaffected. The

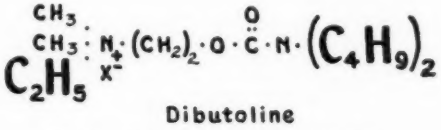

Fig. 7.—Chemical formula of dibutoline.

intraocular effects of dibutoline, therefore, simulate paralysis of the oculomotor nerve and are the reverse of those of acetylcholine.

The action of dibutoline and of di-n-butylcarbaminoylcholine sulfate seems to be peripheral, but the exact nature of the action has not been fully established. The most plausible theory is that the new drugs act as "inhibitory analogues" of acetylcholine. An "inhibitory analogue" is a compound which, by virtue of its chemical similarity to a normal metabolite, replaces the latter in the tissues but is incapable of fulfilling its metabolic functions; consequently, physiologic functions dependent on the presence of the normal metabolite are interrupted. There are numerous examples in bacterial metabolism, notably paraaminobenzoic acid and paraaminobenzenesulfonamide (sulfanilamide). The latter is thought to inhibit the multiplication of certain bacteria by competing with the normal metabolite, paraaminobenzoic acid, for enzymes essential for growth. A similar relation may exist between the new series of choline-like esters and acetylcholine. Acetylcholine normally is involved in the mediation of nerve impulses to tissues like

13. Swan, K. C., and White, N. C.: Di-n-butylcarbaminoylcholine Sulfate: New Cycloplegic and Mydriatic Drug, Arch. Ophth. **31**:289 (April) 1944.

14. Swan, K. C., and White, N. C.: Am. J. Ophth. **27**:933, 1944.

the iris sphincter and the ciliary muscle. The new compounds are chemically similar to acetylcholine, but they are surface active and would be expected to have greater affinity for the tissues. If the new drugs displaced acetylcholine from the muscle receptor system but were incapable of fulfilling their role in the normal transmission of nerve impulses, relaxation of the involved muscle would result.

The ocular effects of the dibutoline, alone and in combination with other drugs, have now been studied on over 1,000 patients. The initial reports were made with carefully controlled doses on a rather limited number of cooperative patients, and it was assumed that the compound penetrated the cornea readily because of its high surface activity.[15] Later studies have shown that this assumption was not justified; moreover, a few patients seem refractory to dibutoline. The ocular effects and clinical applicability of dibutoline must, therefore, be reevaluated.

Taylor [16] developed a quantitative method for the analysis of dibutoline in the tissue that has made possible accurate determinations of the rate of penetration of dibutoline into the eye. These quantitative chemical studies indicate that the dibutoline, despite its high surface activity, penetrates the normal cornea rather slowly. It penetrates the corneal epithelium but, like other highly surface-active compounds, seems to be retained in this layer. Also, because of its high affinity for water, a good part of the drug tends to remain in the conjunctival secretions and is washed away with the tears.

Extensive clinical experiments have confirmed these laboratory observations that dibutoline, like other choline esters, may be quite inconsistent in its action unless precautions are taken to insure its corneal penetrability. Unfortunately, the "law of relative affinities" cannot be applied to dibutoline. Unlike carbachol and acetylcholine, dibutoline cannot be administered to the cornea in an anhydrous base because it produces injury when concentrated in the epithelium. The epithelial injury that occurs in these circumstances is characteristic of that produced by all highly surface-active agents.[17]

Despite the relative inconsistency of corneal penetration, dibutoline has properties which give it a definite place in ophthalmic therapeutics. In the intensity of its ocular effects the new compound is comparable to homatropine. In most patients it is as effective a cycloplegic as homatropine but is a weaker mydriatic. With homatropine, the busy ophthalmologist cannot depend on pupillary size and reaction to determine whether adequate cycloplegia exists, because the mydriasis is far more intense and prolonged than the cycloplegia. In contrast, dibuto-

15. Swan, K. C., and White, N. C.: Dibutoline Sulfate: New Mydriatic and Cycloplegic Drug, Arch. Ophth. **33**:16 (Jan.) 1945.

16. Taylor, J.: To be published.

17. Swan, K. C.: Am. J. Ophth. **27**:1118, 1944.

line has nearly equal effects on the iris and the ciliary muscles; consequently, size and reactivity of the pupil provide a reliable and convenient indication as to the state of cycloplegia. The ocular effects of dibutoline are considerably less prolonged than those of homatropine. Effects of a maximal dose of the drug wear off completely within sixteen to twenty-four hours in the average adult. Dibutoline also differs from homatropine in that undesirable systemic symptoms do not follow its ocular administration in children.

Dibutoline is of greatest value in cycloplegic refraction and internal examination of patients from 35 to 50 years of age. In this age group it produces satisfactory cycloplegia, with a shorter period of visual disability, and there is less danger of precipitating glaucoma than when homatropine is used. The most effective means of administering dibutoline in adults is to precede it with a drop of a local anesthetic to disturb the epithelial barrier. For example, it is the custom in the University of Oregon Medical School Clinics to determine intraocular tension of all adults prior to dilation of the pupils for internal examination. A drop of 0.5 per cent tetracaine hydrochloride is instilled, and the tonometric measurement is made; then two instillations of 5 per cent dibutoline sulfate are effectively absorbed in almost all adults.

The cycloplegic action of dibutoline, like that of homatropine, is too weak to permit use of the drug alone for refraction in children, but in combination with scopolamine dibutoline is valuable because it has low toxicity and a short duration of action. The drug does not produce the circulatory disturbance and excitation and depression of the nervous system which characterize the toxic effects of atropine, homatropine and other drugs of that series. It is my practice to administer to small children a single instillation of 0.2 per cent scopolamine hydrobromide. This dose generally effects a partial cycloplegia and is usually the largest dose which can be administered to small children without evidences of systemic toxicity, such as drying of the secretions and flushing of the face. Rather than wait until the systemic effects of scopolamine wear off before another dose is administered, the cycloplegia is completed with several instillations of 5 per cent dibutoline sulfate. Serious systemic disturbances do not occur, even in infants, and satisfactory mydriasis and cycloplegia often can be obtained in a few hours.

Dibutoline, because of its surface activity, has antiseptic and detergent properties; therefore, it is a valuable drug to be used in cases of laceration of the cornea or infective keratitis, not only to reduce irritation of the iris and ciliary processes but to cleanse the conjunctival sac and to control infection. For this purpose dibutoline is more ideal than any of the previously known compounds. Finally, it may be necessary to use dibutoline as a substitute for drugs of the atropine series in patients

who are allergic to the latter. Dibutoline is chemically unrelated to this group of drugs, and as yet no allergic reactions have been observed. The action of the drug is not sufficiently prolonged for routine use in the treatment of uveitis. For this purpose, scopolamine is more nearly ideal.

COMMENT

In this presentation of the ocular effects of some choline derivatives, emphasis is placed on the action of these drugs on the intraocular muscles. These effects are readily subject to careful laboratory study, and a considerable body of data has been obtained. In clinical studies the action of drugs on glaucoma is also subject to careful analysis. As a result, the influence of these drugs on the intraocular tension is fairly well established. There are other ocular effects of these compounds which remain to be investigated, and which may lead to the development of new and more effective therapeutic agents. For example, the choline esters, which are miotics, and the drugs which enhance the physiologic action of acetylcholine are among the most effective agents in the control of glaucoma, but relatively little is known about their effects on the intraocular vascular system and the secretory mechanism of the ciliary body. Only a limited amount of work has been done on the action of these compounds in the biochemistry of the intraocular fluids. It is known that the constituents of these fluids are altered by such drugs as methacholine and that the penetration of various compounds from the blood into the intraocular fluid is influenced.[18] The full physiologic and clinical significance of these facts remains to be established.

The possibility of synthesis of new choline esters of pharmacologic importance has not been exhausted; e. g., no systematic efforts have been made to synthesize derivatives of miotic choline esters with more consistent corneal penetrability. If the hydrophilic properties of the choline derivatives could be reduced without modification of their pharmacologic effects, the value of these compounds in clinical ophthalmology would be greatly increased. Finally, the possibility of synthesis of new mydriatic and cycloplegic drugs of the class discovered by Swan and White has not been extensively investigated. It is quite possible that more effective compounds of this series can be developed. Certainly, none of the currently available mydriatic and cycloplegic drugs are ideal for routine cycloplegic refraction and internal examination of the eye.

SUMMARY AND CONCLUSIONS

A decade of laboratory and clinical experiences with the ocular effects of choline derivatives is reviewed. As yet, it is not possible fully to evaluate the influence of these drugs on the intraocular vascular

18. Swan, K. C., and Hart, W.: Am. J. Ophth. **23**:1311, 1940.

system or on the metabolism of the intraocular tissues, but their effects on the muscles of the iris and ciliary body and on intraocular tension seem fairly well established.

The choline esters are hydrophilic and when instilled into the conjunctival sac in simple aqueous solution tend to be retained in the water of the vehicle. In accordance with the "law of relative affinity," choline esters, such as carbachol (carbaminoylcholine chloride), are most effectively administered when suspended in an anhydrous base. When so administered, the drug has a relatively higher affinity for the tissue than for the anhydrous base, and corneal penetration is fairly consistent.

The epithelium, with its lipoprotein constituents, is the main barrier to the penetration of the choline esters. Disturbance of this barrier by physical or chemical means may increase the corneal penetration of certain choline esters a hundred fold. The ocular effects may be greatly enhanced, but dangerous systemic reactions may occur.

Acetylcholine is associated with the transmission of stimulatory nerve impulses to the sphincter of the iris and to muscles of accommodation, but its action is so evanescent and its absorption so inconsistent that it has little practical use in ophthalmic therapeutics. The physiologic effects of acetylcholine can be greatly enhanced and prolonged by drugs, such as physostigmine, neostigmine and di-isopropyl fluorophosphate, which inhibit the choline esterase. These indirectly acting stimulants effect a sharp, relatively spastic contraction of the intraocular muscles and increase the tonus of the orbicularis muscle. As their effects wear off, these muscles become hyperreactive. The drastic and inconsistent changes in accommodation, the spastic action of the pupil and the hyperreactivity of the orbicularis muscle which these drugs cause, largely limit their use to the treatment of acute congestive glaucoma. Di-isopropyl fluorophosphate (DFP) seems particularly effective in cases of aphakic glaucoma, but until further studies are made it should be used with caution in cases of postinflammatory glaucoma.

Methacholine chloride (acetyl-beta-methylcholine chloride; mecholyl® chloride) has more prolonged direct stimulatory effects than those of acetylcholine but must still be classified as a short-acting miotic. It is an important drug in the treatment of acute congestive glaucoma of the shallow chamber type. In this condition it has an advantage over drugs like physostigmine in that the systemic effects are not accumulative. Extreme miosis can often be obtained in a matter of minutes when the drug is administered to the cornea by iontophoresis. A rapid drop in tension follows.

Carbachol U. S. P. (carbaminoylcholine chloride; carcholin®; doryl®) and the urethane of beta-methylcholine chloride (carbaminoyl-beta-methylcholine; urecholine®) are choline esters with prolonged stimula-

tory action on the intraocular muscles. Their hypotensive action in cases of chronic noncongestive glaucoma is more intense and prolonged than that of pilocarpine. They are often effective when pilocarpine fails to control the tension; however, precautions must be taken to insure corneal penetration of these drugs. Special vehicles and massage of the cornea through the lids are required, and the patient must be intelligent and cooperative. In accordance with the "law of relative affinities," these drugs are most effectively administered as a suspension in an anhydrous ointment base.

The pharmacologic action of the choline esters seems related to their surface activity. The miotic and cyclotonic drugs are all relatively surface inactive, whereas the highly surface-active esters of choline seem to have mydriatic and cycloplegic properties. My colleagues and I have synthesized a large number of these compounds, but the possibilities have not been exhausted. Dibutoline seems the most effective of the new class of drugs. It seems to act as an inhibitory analogue of acetylcholine and therefore effects paresis of the sphincter of the iris and the ciliary muscles without affecting the dilator of the iris or the smooth muscles of the lids.

Dibutoline, in the intensity of its mydriatic and cycloplegic action, is comparable to homatropine, but it is less consistently absorbed into the cornea and some patients are refractory to its action. When preceded by instillation of a topical anesthetic, dibutoline is more consistently absorbed and is sufficiently potent to be used as a routine cycloplegic in older adults. It has the advantage that the visual disability which it causes is not so prolonged as that of homatropine, and the size and reactivity of the pupil provide a convenient indication of the degree of cycloplegia. The drug has low systemic toxicity; therefore, it is useful as an adjunct to scopolamine or atropine to produce cycloplegia in children.

In the management of corneal inflammations, dibutoline is valuable because it has detergent and antiseptic action and its mydriatic and cycloplegic effects are not unduly prolonged. Dibutoline is not ideal for the routine treatment of uveitis but fills an important need when the patient is allergic to the atropine series of drugs.

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SURGICAL TREATMENT OF RECURRENT PTERYGIUM

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PRIOR to World War II recurrent pterygium had been a matter of little concern to most ophthalmologists in the United States. The few patients with primary pterygium who consulted the individual surgeon were handled with satisfaction to both the patient and the physician. Many ophthalmologists had seen no procedure other than McReynolds' transplantation or one of its minor modifications. They were for the most part unaware of the number of papers describing other technics, designed to avoid recurrence, written by men in sections where pterygium is common. The need of this knowledge did not exist for most ophthalmologists in this country. Recurrences were so rarely encountered that one did not inquire into the surgical treatment.

There is a vast difference between an operation for primary pterygium and the surgical management of recurrent pterygium. The first operation is simple and is attended with such a high degree of success that it serves well to introduce the beginner to the field of ophthalmic surgery. On the other hand, the many published technics which have been developed to eradicate the small percentage of recurrent pterygiums attests to the difficulties which beset even the experienced ophthalmologist in dealing with them.

When several patients were admitted to Valley Forge General Hospital in early 1944 with histories of having had from two to twelve previous operations for pterygium, each operation being followed by a recurrence of greater severity, the personnel of the ophthalmology section was unaware of the difficulties associated with this problem. Since practically all forms of treatment had already been tried without avail, it was evident that a different technic must be developed to meet this situation.

As shown in figure 1, the recurrent lesions were thick and extensive. Several patients had symblepharon, ptosis and limitation of motility

This article is a condensation of a thesis accepted by the Committee on Theses of the American Ophthalmological Society in partial fulfilment of the requirements for membership. The bibliography is given in full, but all case reports and the sections on incidence, etiology, pathology, history of surgical treatment, complications, effect on refraction and animal experiments have been omitted, for the sake of brevity.

severe enough to produce diplopia. It was obvious that in all these patients extensive excision of scar tissue was necessary as a first step in any surgical treatment.

In 1942, at the Institute of Ophthalmology in New York, I had been privileged to remove a highly vascularized intraepithelial epithelioma in an elderly patient; the growth covered the entire cornea and extended about 6 mm. beyond the limbus in all quadrants of the eye. The operative procedure consisted in complete superficial keratectomy and excision of 8 mm. of involved conjunctiva and the episcleral tissue around the entire circumference of the cornea. It was impossible to mobilize enough conjunctiva to cover the exposed sclera. Mucous membrane or skin grafts were avoided, as they would render recog-

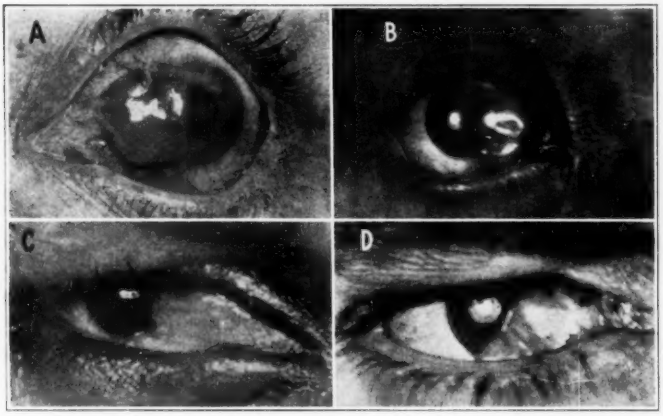

Fig. 1.—Four pictures showing the various types of recurrent pterygiums discussed in this paper.

nition of recurrent tumor tissue difficult. The free borders of the conjunctiva and Tenon's capsule were sutured to the outer layers of the sclera at a distance of 7 mm. from the limbus. The large area was left without conjunctival covering with the hope that it would epithelize. Healing was kindly, and there was no staining with fluorescein after ten days. This was a happy result for so radical a procedure, and one which would at first seem to be contrary to accepted surgical principles. Dr. George Wise, of New York, who reported on this case in 1943, states that the tumor has not recurred, nor has there been any vascularization of the cornea during the past six years.

It seemed possible that this technic might be modified for use in preventing recurrence and vascularization of the cornea after complete excision of the recurrent scar tissue in cases of pterygium.

The first patient had had four operations, the last being a transplantation of oral mucous membrane to cover a large defect left after excision of recurrent pterygiums. The photograph (fig. 2*A*) shows the appearance of the eye. The unsightly graft extended 5 mm. onto the cornea and was elevated about 3.5 mm. It was productive of foreign body sensation and caused pronounced astigmatism. The patient had diplopia on lateral gaze. Since in all previous operations the conjunctiva or mucous membrane had been sutured at the limbus, it was felt that excision of the graft and of all scar tissue, if combined with recession of the conjunctiva, might prevent recurrence and eliminate the restricted mobility of the eyeball. Through the cooperation of Dr. James N. Greear Jr., then Lieutenant Colonel (M. C.), chief of the Eye Section at Valley Forge General Hospital, it was decided to try this technic, and he performed the first operation. The operation was successful and there has been no recurrence in the three and one-half years since operation. The cosmetic result was excellent, as shown in figure 2*B*. The pronounced corneal astigmatism was largely elimi-

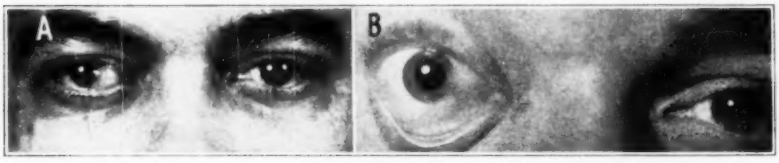

Fig. 2.—*A*, preoperative appearance of mucous membrane graft applied in fourth operation; *B*, postoperative appearance. The gray area is not elevated.

nated. Only a few blood vessels extended onto the cornea, and these were visible only with the slit lamp.

Encouraged by this result, operations were done on other soldiers, with equally good results. In the thesis of which this paper is a condensation, 29 operations, performed on 22 patients, are reported.[1]

The principles of the operative technic to be described have also been applied to pseudopterygiums, to excision of epibulbar tumors, to the correction of symblepharon and to the removal of superficially vascularized corneal scars.

OPERATIVE PROCEDURE AND RESULTS

Operative Technic.—A superficial lamellar keratectomy is done. The incision is started with a Graefe or a Lunsgaard knife 0.5 to 1 mm. central to the advancing border of the recurrent vascularized connective tissue and is carried back to the

1. Since the thesis was completed, operation has been successfully performed on 9 additional patients at the Valley Forge General Hospital. Two other patients had recurrences, as a result of faulty technic.

limbus in one plane as deep as necessary in order to include all scar tissue. A black silk traction suture placed through the head of the pterygium is useful during the keratectomy for fixation and retraction. Any shreds of connective tissue are carefully removed with the knife or a sharp curet. The dissection is carried beyond the limbus with a Lunsgaard knife, or sharp dissecting scissors if desired. When the dissection is completed to the point where the bulbar conjunctiva is no longer tightly adherent to scar tissue, Stevens scissors are used to undermine the healthy conjunctiva back to the semilunar fold and for about 8 mm. superior and inferior to the borders of the offending scar tissue (figs. 3 to 7).

In some instances the recurrence is made up purely of scar tissue; in others there are what appear to be portions of the original tissue of the pterygium. The amount of conjunctiva adherent to this tissue varies a great deal. It is advisable to save as much healthy conjunctiva as possible as one excises all the recurrent scar tissue. Therefore submucous excision, as advocated by several surgeons, can be done to advantage. It should be noted that one is attempting to recess, rather than to excise, conjunctiva. However, it is necessary to excise all the scar tissue and abnormally adherent conjunctiva over it, as this subconjunctival tissue gives rise to recurrence of the lesion if left in place. Whatever conjunctiva can be saved is recessed to serve as lining for the superior, nasal and inferior fornices, which have often been obliterated to some extent by previous operations. This prevents or corrects symblepharon with the limitation of motion and ptosis which are present in such cases. Sutures on rubber pegs can be passed from the fornices through the lid and tied on the skin surfaces to hold the conjunctiva in place in the fornix, in cases of extensive symblepharon, as advocated by Berens.

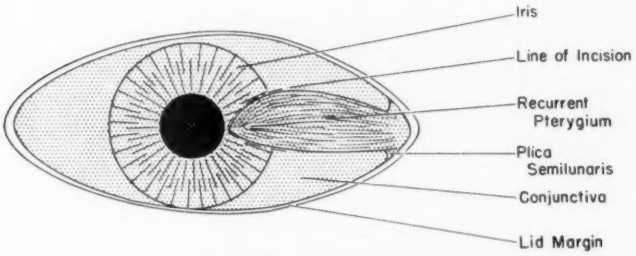

Fig. 3.—Preoperative appearance and lines of incision. In this diagram and in figures 4 to 7 the scheme for designating tissues is as follows: intact epithelium, dotted areas; ocular muscle tendons, horizontally hatched areas; episcleral scar tissue, obliquely hatched areas, and bare sclera, clear areas.

After the excision of the scar tissue forming the body of the recurrent pterygium is completed, one often finds still denser connective tissue adherent to the sclera. In 6 cases this scar tissue extended from the nasal border of the tendon of the superior rectus to the nasal border of the tendon of the inferior rectus and outward beyond the insertions of these tendons. This tissue is also excised by sharp dissection, a procedure which is unavoidably tedious and time consuming. It is particularly necessary to excise that portion lying at or near the limbus, and this is just the area where such dissection is troublesome, because

of previous operations and because the sclera is rather thin over the intercalary zone. If a Graefe knife is used for the keratectomy, there is likelihood that one of the incisions may be unduly deep because of the difference in consistency of corneal stroma and the recurrent scar tissue. After such a deep cut has been made, it is difficult to complete the dissection cleanly peripheral to the cut and beyond the limbus. In 2 cases the remnant of connective tissue at this site gave

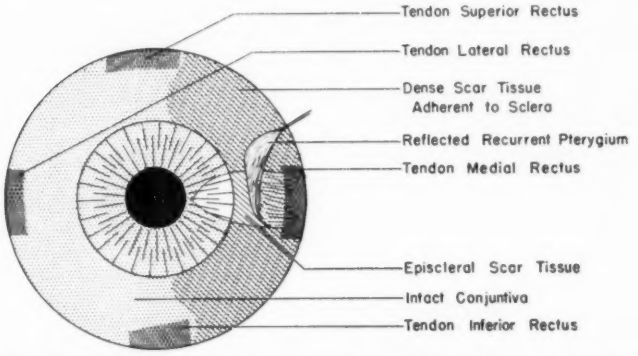

Fig. 4.—Extent of peculiar dense scar tissue tightly adherent to the sclera. It is found only when the conjunctiva is undermined and reflected. It is excised by sharp dissection.

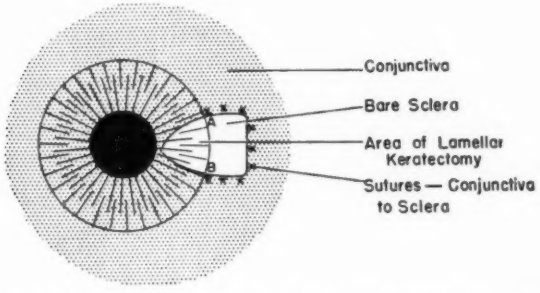

Fig. 5.—Appearance at completion of early operative procedure. Proliferation of vascularized connective tissue may invade the cornea at points *A* and *B*.

rise to neovascularization, which marred an otherwise perfect result. The Lunsgaard knife or a corneal splitter, therefore is preferable to a sharp-pointed knife.

One often finds a few superficial bleeding points. These are touched with a cautery tip, as it is found that such areas may give rise to new blood vessels which may extend onto the cornea, although they do not necessarily have enough supportive connective tissue to alter the gross clarity of the cornea. The anterior ciliary vessels are studiously avoided.

At this point, the portion of the cornea previously involved by the recurrent pterygium and a large area of the sclera have been laid bare. The cut edges of the conjunctiva and Tenon's capsule lie loose. In almost all other operations recorded in the literature, this defect has been covered by sliding or free grafts of conjunctiva, by skin grafts, by mucous membrane grafts, by amniotic membrane grafts or by Tenon's capsule and its subconjunctival component mobilized from the adjacent regions. The distinctive feature of the procedure presented here is

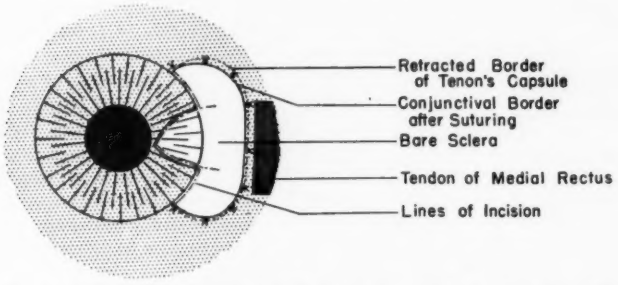

Fig. 6.—Appearance at completion of operative procedure, showing perilimbal incisions and recession of conjunctiva away from the area of keratectomy.

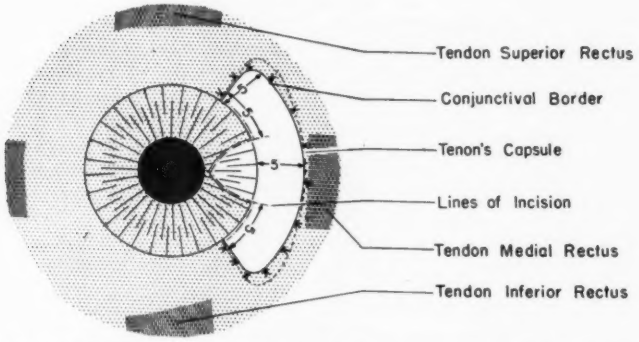

Fig. 7.—Diagram of second revision of procedure, showing radical recession of conjunctiva to prevent vascularization of cornea. The dimensions are expressed in millimeters.

that the conjunctiva is recessed and sutured to the sclera proper at least 5 mm. from the limbus and that the defect is allowed to epithelize by itself.

Because it seemed that blood vessels and connective tissue gave rise to the reformation of the scar tissue onto the cornea, an attempt was made to eradicate all such subepithelial tissue. Any graft heals by connective tissue binding it in place. Epithelium grows so rapidly and so close to the cornea and sclera that the wound heals before much connective tissue is formed. With kindly healing

and with the exercise of care to prevent irritation of the operative area, the stimulus to formation of subepithelial connective tissue is reduced to a minimum, and the process of repair is completed before granulation tissue is formed. One effects healing in this case not by "allowing the wound to granulate in" but by allowing the defect to become epithelized quickly.

With the aim of rapid epithelization in mind, certain details in suturing the conjunctiva to the sclera are watched with care. First, the outer layers of the conjunctiva are separated from the submucosa and Tenon's capsule as precisely as possible. The capsule is allowed to retract, while the thin, healthy conjunctiva alone is sutured as follows: A double-armed 0000000 black silk suture on atraumatic needles is used. One needle is passed through the outermost layers of the sclera with as little trauma as possible. The needles are then passed from within outward through the conjunctiva about 2 mm. apart, and the suture is then tied. This procedure flattens the conjunctiva against the sclera proper. Usually eight or ten such sutures are used. Care is taken to cover the insertion of the tendon of the medial rectus muscle, which has been disturbed as little as possible in the previous dissection. Tenon's capsule over the tendon is repaired if it has inadvertently been perforated or if it has been involved in the scar tissue mass. The importance of this precaution has been shown by Berens and Romaine.

In the early cases the conjunctiva was not incised along the limbus above and below the vertical limits of the recurrent pterygium. This angle was the site of the formation of new blood vessels. Later, a limbal incision was made 3 mm. above and below the head of the pterygium and the suturing completed, as shown in figure 6. This was usually satisfactory, but this angle also tended to be too acute in some cases. Hence, more mathematically logical incisions can be made 5 mm. above and below the limbal junction of the keratectomy site. This allows recession of the undermined conjunctiva 5 mm. from the limbus at all points and gives an angle of almost 90 degrees. The conjunctiva from point *A* is then sutured to the sclera, 5 mm. away (fig. 7). This, of course, makes a small ruffle of redundant conjunctiva above this area, but it is of no consequence, merely furnishing deeper fornices, a feature much to be desired in the cases in which symblepharon has produced ptosis and limitation of motion. It may be emphasized again that no limitation of motion results from this procedure, because, although conjunctiva (really epithelium) is tightly adherent to the globe nasally, the recession of conjunctiva and Tenon's capsule allows free mobility of the globe and eyelids.

When all the sutures are tied, the eye appears as shown in the sketches (fig. 8). Boric acid ointment, 5 per cent, is applied to the eyeball; the lids are carefully closed, and a pressure dressing is applied.

It is preferable to bandage both eyes for five to seven days, but this was done in only about half the cases. A tight pressure dressing is used.

Postoperative Course.—The dressing is left in place for four days, and the second dressing is reapplied in the same manner as the original one. Redressings are done every other day until the tenth day, when the sutures are removed. Staining with fluorescein is usually absent after the sixth or seventh day, sometimes being absent after the fifth day. In removing the sutures, care is taken not to incite bleeding or to disturb the tissues, lest more scar tissue be formed. If the subconjuntival tissue has been carefully dissected, there is little or no elevation peripheral to the sutures.

In the first cases, in which 100 r of unfiltered roentgen radiation was given on each of the first, second, third and fifth days (a total of 400 r), the dressing had to be removed for the treatments. The reaction

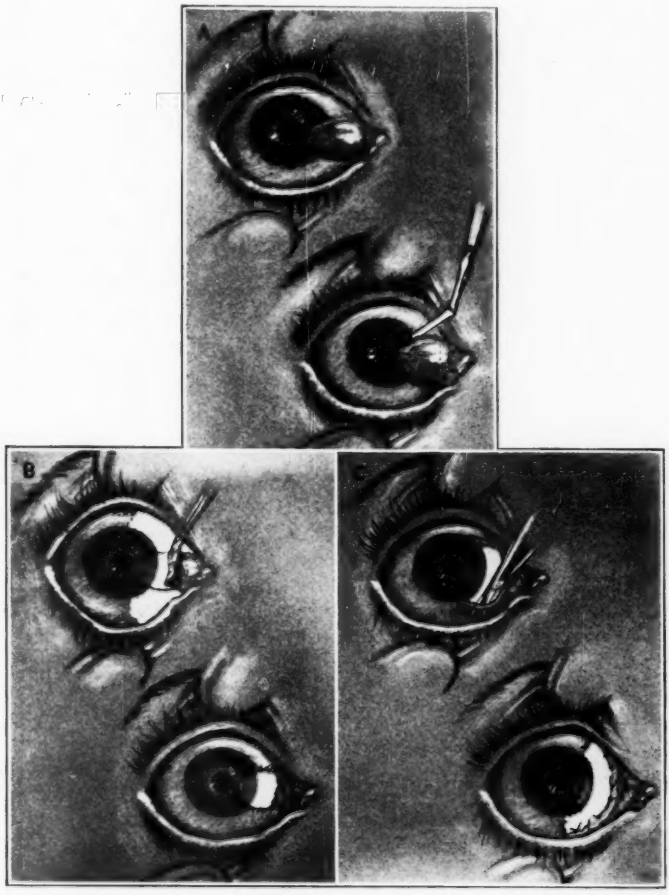

Fig. 8.—Crayon drawings showing the operative procedure for removal of recurrent pterygiums.

was greater as a result of this frequent manipulation. It is often unnecessary to consider any form of radiation therapy. It is now felt that the cornea should be observed carefully and that if any new blood

vessels appear treatment with beta radiation should be started promptly. This method is considered most satisfactory for handling vascularization in corneal transplants and it serves the same purpose for postoperative pterygiums.

Antibiotic therapy was not used, for we wished (1) to avoid allergic reactions, which might have an adverse effect and promote scar tissue formation, and (2) to determine whether this procedure is more likely to be complicated by infection than are other procedures. No clinical signs of infection occurred in any case. There has been no evidence of disturbance of nutrition of the cornea.

Atropine was used in about half the cases and no cycloplegic in the other half. In no instance did examination with the slit lamp show aqueous flare or cells, and synechias did not form. Hence, one may conclude that the use of a cycloplegic after operation is optional.

End Result.—For four to six weeks after operation the area nasal to the limbus appears too white, and close inspection reveals a slight concavity. Although the epithelium seems tightly adherent to the sclera over this entire area, blood vessels and a thin layer of supporting connective tissue grow toward the limbus, producing a more nearly normal-appearing bulbar conjunctiva.

The blood vessels tend to arborize as terminal branches, which end at or near the limbus. In a few cases the vessels reached the corneoscleral junction and then pursued a course parallel to it. In a few cases the vessels actually encroached on the cornea, but in only 1 case did a true recurrent pterygium develop. These vessels are readily obliterated by beta irradiation. In checking back on these cases, it was found that when any vessels passed the corneoscleral junction one of two factors present at operation had been responsible: (1) A little connective tissue had been left in place, (2) the conjunctiva had not been incised along the limbus far enough above and below the head of the pterygium to allow proper recession of the conjunctiva.

During the postoperative period these patients remained sheltered in an area (Pennsylvania) where the incidence of pterygium is low. This factor has undoubtedly been helpful. Whether such successful results would be obtained if this procedure were tried in South Africa, Panama, Egypt, the South Pacific or other areas where recurrence is known to be frequent remains an open question. However, other procedures tried at Valley Forge General Hospital were not effective, and the technic described here was eventually employed in every case of recurrent pterygium.

During the time of active military duty, it was impossible to make a satisfactory study of surgical methods other than those described in standard textbooks. The technic employed was serving its purpose well for the patients at one large hospital designated as a surgical eye

center. After the war it was found that not a few medical officers in the Army and Navy had found recurrent pterygium a problem in various parts of the world. More interest was then evinced in the method which had finally been successful in eradicating the multiple recurrences. Additional patients in both civilian and Army practice have been seen with similar lesions requiring treatment.

A thorough review of the literature was therefore undertaken. The results of this review have been condensed in order to bring up to date the pertinent data regarding pterygium under the headings of incidence, etiology, pathology, the causes of recurrence and the surgical treatment of both primary and recurrent pterygium. These topics are discussed briefly in relation to the surgical technic described in this paper.

While the technic was original so far as I actually knew, it is interesting, although not surprising, that the salient features were described independently by various authors about fifty years ago. What one now has is a combination of surgical principles and technical details described piecemeal long ago and apparently neglected over a considerable span of years.

HISTORY OF SURGICAL TREATMENT OF PTERYGIUM

The historical aspects of pterygium therapy are interesting in that there has been no gradual evolution to an optimum method, in keeping with the advances in general or ophthalmic surgery. Only those procedures which are similar to the one described in this paper are reviewed here. The remainder of the history of the surgical treatment has been omitted.

Boeckmann, in 1897, reported a procedure which he had used for fifteen years. He regarded excision as multilating, the only excuse for it being that it was followed by good results! He compared the surgical treatment of pterygium with that of a fracture: The pterygium is a dislocation of conjunctiva, which requires reposition and fixation. He dissected the head from the cornea and from the sclera, excised all subconjunctival connective tissue and sutured the retracted border of the conjunctiva to the medial rectus muscle at its insertion. This left the conjunctiva in direct contact with the sclera and a triangular area of denuded sclera adjacent to the fresh corneal wound. He depended on tight adhesion between the conjunctiva and a rapidly forming cicatrix "to prevent recurrence for all time."

Lopez, of Habana, in 1898, advocated excision near the base, strangulation of the base, incisions bordering the limbus above and below the pterygium and dissection of these portions of the conjunctiva to prevent their adhesion to the denuded cornea. He used no sutures, simply leaving the borders of the conjunctiva to retract until after the corneal epithelium had regenerated.

Steiner, in 1911, described a new operation which he used in 7 cases of pseudopterygium, a lesion which, of course, is much like many recurrent pterygiums. He dissected the pseudopterygium from the cornea and sclera down to the fornix. He recessed the head and fastened it in the upper (or lower) fornix, using Snellen type sutures to fix it there and to deepen the shallow fornix. He left the sclera bare, to be covered with epithelium in eight or ten days. He stated that little by little, even after the corneal and scleral defect had healed, this transplanted margin of the conjunctiva slowly crept toward the cornea, and in some cases passed a little beyond its margin. However, in no case did it reach the center of the cornea to disturb vision, as before. There were no ill effects. He stressed the advantage of not sacrificing any conjunctiva, but of using it for deepening the conjunctival sac by recession of the border.

Mendoza, in 1931, described his treatment of recurrent pterygium with reduction in size of the conjunctival sac and restricted ocular mobility. He recessed the entire pterygium, sutured the head to the episclera and left the bulbar wound open. He made no mention of excising any scar tissue, although his procedure was successful in patients who had had several previous operations, including conjunctival transplants and grafts of labial mucous membrane.

In Busacca's procedure, described in 1938, it is difficult to follow the combination of transplantation, submucous resection, grooved incision near the caruncle and double cauterization of the area of sclera left bare between the margin of the pterygium and the limbus. However, he effected a recession of 3 to 4 mm. of the conjunctiva from the limbus and left an area of bared sclera to become epithelized. He reported recurrences.

These procedures are similar to the technic presented in this paper in two particulars: in recessing the conjunctiva to deepen the fornices or to prevent its adhesion to the denuded cornea, and in leaving a portion of the sclera bare, to become epithelized. These procedures differ in the over-all extent of the recession, in failure to excise all episcleral connective and scar tissue and in not suturing the conjunctival border to the outer layers of the sclera proper—all features considered of prime importance in preventing the late creeping up of vascularized connective tissue under the epithelial covering of the sclera. Dr. Arnold Knapp stated that he learned early the advisability of suturing the tissues to the sclera.

D'Ombrain has recently published an account of his extensive experience in the surgical treatment of 1,500 primary pterygiums in Australia. In general, he advocates leaving bare sclera to become epithelized after excising the head of the pterygium and all subconjunctival tissue as

far nasally as the plica semilunaris. D'Ombrain uses no sutures, nor does he recess the conjunctiva above and below the vertical borders of the pterygium. His account is concerned mostly with operations on primary pterygiums. He stated, "This technique may be successfully used in recurrent pterygium but in cases of second recurrence the free graft method . . . should be used." It would be interesting to see what results he might obtain in Australia by adding to his procedure the refinements described for cases of multiple recurrence. It was gratifying, indeed, to learn of D'Ombrain's excellent results with his technic, an operation which is basically the same as that advocated in this paper.

Lombardo recently described recession of the conjunctiva for pannus of trachoma but made no mention of pterygium.

No entirely satisfactory single explanation for recurrence of pterygium has been brought forth. From the surgical standpoint, recurrence following operation has been attributed by various authors to the following factors: (1) incomplete dissection of the head of the pterygium from the cornea; (2) incomplete or impermanent removal of the original pterygium tissue from the area of the palpebral fissure regardless of the method employed; (3) remnants of connective tissue left adjacent to the corneoscleral junction at operation; (4) failure to have healthy conjunctiva extending to the limbus. Some authors have stated the belief that it is essential to have the conjunctiva approximate the corneoscleral junction precisely; others allow it to overlap; a few have stated that it is wise to leave a small gap between the border of the conjunctiva and the corneoscleral junction. Only a very few authors have recommended actual recession of the conjunctiva, and then usually in operation for recurrent lesions.

In addition to the first three points listed in the preceding paragraph, the following factors are held responsible for repeated recurrences: (1) failure to excise all scar tissue from cornea and episclera; (2) failure to occlude all blood vessels in the area of the recurrence; (3) reexposure after operation to the same factors which seemed to cause the original pterygium (that is, the patient remains in the same environment); (4) failure to suture the conjunctiva to the sclera; (5) failure to recess conjunctiva at least 5 mm. from the limbus; (6) too early reoperation; (7) use of grafts which are too thick, the extra thickness denoting vascularized connective tissue, which permits recurrence.

McReynolds, Ryerson, Francis, Pochissoff, Hirschberg and Mendoza described cases of particularly severe recurrent lesions. Gifford, of Omaha, cited Herman Knapp as saying that no operation should be performed for severe recurrent pterygiums. Ryerson avoided sur-

gical intervention in some cases in which the pupillary area of the cornea was involved. He employed optical iridectomy, citing Noyes's statement that this might be the best method of dealing with an extremely severe lesion, although Noyes had added, "but I have never seen such a condition."

McReynolds, when asked by some of his colleagues what he did in severe cases with multiple recurrences, replied that he "regretted that the answer was not more favorable." After stating that he had tried thoroughly every imaginable method of destroying the recurrent growth, he eliminated all chemical and electrical methods as ineffective, since "they lead to severe reaction which in turn produces a correspondingly large amount of scar tissue, the evil genius of ophthalmic surgery." He advocated complete excision of all scar tissue, with preservation of the conjunctiva, which he sutured firmly to the sclera. Presumably he sutured it at the limbus, as he stated that his method was satisfactory when there was adequate conjunctiva, and used skin or mucous membrane when there had been too much destruction of conjunctiva. In none of his papers did he mention leaving the sclera bare to become epithelized. He concluded, "Finally there are some cases in which there has been so much destruction of tissue and so much scar formation that one might just as well refrain from any operative procedure."

These four opinions emphasize the obstinacy of recurrent pterygium in some cases. It is noteworthy that none of the authors cited attempted recession of the conjunctiva, as done by Boeckmann, Steiner, Busacca, Mendoza and me, and that none recorded more recurrences in any one patient than occurred in a case of the present series. It does not seem logical to avoid surgical treatment in the severest cases. It might be better in some cases to avoid surgical intervention for minor pterygium in the first place.

Radiation Therapy.—Radiation therapy has been employed by various men (1) in treatment of primary pterygium, (2) in treatment of recurrent pterygium and (3) as a postoperative measure to prevent recurrence or to eliminate vascularization of the cornea. It is generally agreed that the eye should not be subjected to any form of radiation unless there is good reason for so doing. Adequate protection of all parts of the eyeball not requiring actual treatment is essential. The dose should be the minimal effective one.

Reports of its use should include a statement of all the radiation factors: type of rays, number of roentgens, size of portal, target skin distance, time of application, type and thickness of filters, kilovoltage, milliamperage and half-value layer. Most reports do not give all this

information. In checking the roentgen and beta radiation given to some of the patients in this and in other series, I have been unable to determine all the radiation factors.

Roentgen Radiation: The results of using four applications of 100 r of unfiltered roentgen rays were disappointing, and such treatment was abandoned. Castroviejo reported much better results after using 1,500 r and stated that this dose prevents the formation of and eradicates new blood vessels in corneal transplants and after lamellar keratectomy.

Beta Radiation: The use of beta radiation has been very encouraging. It should be noted, however, that the bulb as used in some hospitals delivers as much as 10 per cent of gamma rays. Although the application time is short, it is felt that some danger exists and that treatment should be given only by persons skilled in the technic of irradiation.

The Phillips tube as employed at the Hospital of the University of Pennsylvania seems a well regulated, safe, precise method of delivering radiation. Some of the patients in this series were treated through the courtesy of Dr. F. H. Adler. No undue reaction occurred. The treatment was available when needed. New blood vessels were unquestionably destroyed when treated soon after their appearance. Other patients were treated under the direction of Dr. Charles Iliff, in Baltimore, according to the technic published by him.

While not enough data are available, it seems safe to state that beta radiation is not effective in completely eradicating primary or recurrent pterygium. It was used prior to surgical treatment in several cases of this series to hasten occlusion of vessels in heavily vascularized recurrent pterygium. The results were better after operation because the limited penetrating power of beta radiation makes its use more effective after the bulk of the tissue has been removed. Later observation leads one to feel that preoperative irradiation should be avoided. Grenz ray therapy was not employed.

Iliff reported successful treatment in 17 of 18 cases of primary pterygium, operation being required in only 1. He published no illustrations. Ruedemann showed colored photographs of patients treated with beta radiation. The end results appeared to be much less extensive corneal involvement and blanching of all blood vessels. He stated that for larger lesions he combines operation and beta irradiation. Trueman has used a similar technic.

To summarize, it is generally felt that, of all methods of radiation therapy, beta irradiation offers the greatest benefit and that its effects are greatest when it is used as a postoperative measure to eradicate newly formed blood vessels in the cornea or those which seem about

to encroach on the cornea. Its use is advised when such blood vessels are found on examination with the slit lamp, and then prompt treatment is advocated. One is wise to make advance arrangements for beta irradiation during the period following operation for recurrent pterygium.

In order to test the practicability of the operative technic presented in this paper, and to be certain that the good results obtained were not simply due to good fortune, several other ophthalmologists have employed it. Their results paralleled those reported here.

SUMMARY

An operative technic developed to eradicate severe recurrent pterygium is described, and its results in a group of Army patients with from one to twelve recurrences are reported. Some of the patients had symblepharon, ptosis and limitation of mobility as a result of the extensive scar tissue.

The results were good after other procedures had failed to prevent recurrence. Although the series of patients is small the procedure is therefore offered for trial by other surgeons with the hope that it may be of value in regions where recurrences are more frequent and more troublesome. The technic is simple and safe, and the essential features are based on logical surgical principles.

This procedure consists, in brief, of lamellar keratectomy, submucous resection of all scar tissue and recession of the conjunctiva by suturing it to the sclera proper at least 5 mm. from the corneoscleral junction, the denuded cornea and sclera being allowed to become epithelized. Beta irradiation is used after operation when it is necessary to control vascularization. This simple technic has also been found suitable for excision of pseudopterygium and epibulbar tumors, repair of symblepharon and removal of superficially vascularized corneal scars.

Recession of the conjunctiva permits deepening of the contracted fornices, with consequent relief of ptosis, symblepharon and diplopia. Revascularization is likewise avoided. No ill effects have been observed from allowing the denuded cornea and sclera to become epithelized.

Although this procedure was developed without known precedent, it was not surprising, on a review of the literature, to find that it is a combination of surgical principles and technical details most of which had been described piecemeal many years ago and then neglected over a considerable span of years. The literature is reviewed, and the information on the incidence, etiology, pathology, causes of recurrence and surgical treatment of primary and recurrent pterygium is presented in condensed form.

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EMBRYONAL CATARACT ASSOCIATED WITH INTERSTITIAL KERATITIS AND SYPHILITIC CHOROIDITIS

Report of a Case

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THE OCCURRENCE of an embryonal cataract associated with interstitial keratitis and syphilitic choroiditis is extremely rare, only 2 previous cases having been listed so far as I have been able to determine. Vogt,[1] who described 1 of these cases, suggested that all instances of such a condition be reported whenever observed, since the cause of this lenticular opacity has thus far not been satisfactorily determined. He stated that among the features not yet clearly understood are the reason for the coloration of the opacity, the relation of the opacity to interstitial keratitis, the eventual progression of this cataract to complete maturity and its mode of development. He did not list this opacity with the complicated cataracts, for he assumed that the disturbance in the lens occurred early in life and first manifested itself as a subcapsular opacity, which subsequently was pushed deeper into the lens through deposition of normal, healthy lens fibers between the capsule and the opacification.

Blaauw [2] reported a case as "circumscribed lamellar lens changes probably inherited." His patient, aged 35, presented an opacity in each lens which was yellow and cloudy, approximately 4.5 mm. in diameter and located within the adult nucleus. In cross section there was a cloudy, yellowish ring completely surrounding the embryonal nucleus. The ring appeared to become thicker at both its superior and its inferior extremity through a process of widening and flattening of the bands. The ring completely surrounded the nucleus, suggesting a globular body. The clear interval was normal, as were both the anterior and the posterior Y's.

The patient reported by Vogt,[1] a woman aged 37, had had two attacks of interstitial keratitis. Her father had had bilateral choroiditis. The biomicroscopic changes in the daughter's lens were interesting but not easy to explain. The abnormality occurred between the border of the middle and that of the posterior third of the lens. The change was

1. Vogt: Spaltlamp Microscopie, Berlin, Julius Springer, 1931, vol. 2, p. 958.

2. Blaauw, E. E.: Circumscribed Lamellar Lens Change Probably Inherited, Arch. Ophth. **54**:305 (May) 1925.

present in the axial region. The opacity was whitish yellow to red yellow and was concavely saucer shaped, occupying the position of one of the discontinuation zones. The opacity was bilateral. The posterior capsule of the lens was relatively flat, whereas the anterior capsule was highly arched. At the time of the acute flare-up of the interstitial keratitis, the lenticular disturbance was subcapsular, but as healthy lens fibers were laid down between the capsule and the opacity the cataract was pushed deeper into the lens substance.

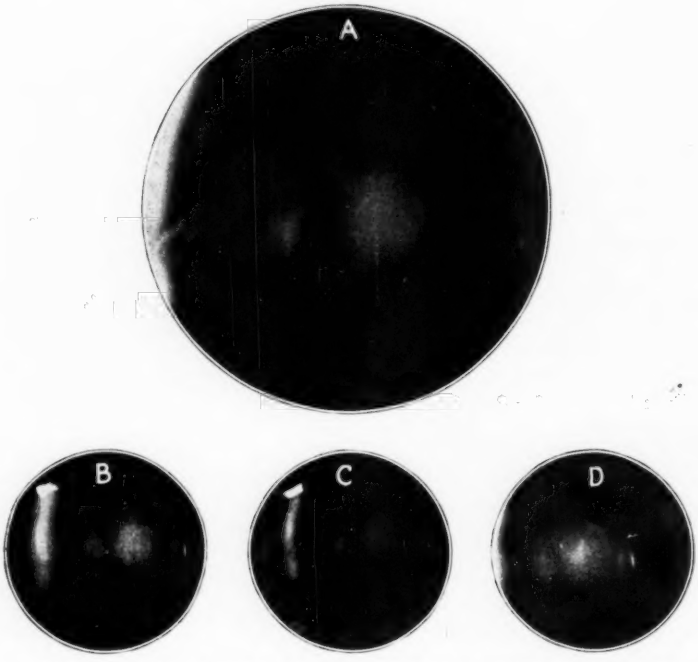

Fig. 1.—*A*, enlarged photograph of the slit beam in passing through the eye. *B*, *C* and *D*, photographs without enlargement, showing the wide beam, narrow beam and light exposure, respectively.

REPORT OF CASE

The patient was born at full term, although weighing only 3½ pounds (1,584 Gm.) at birth. The mother was married at 17 years of age to a man fourteen years older than herself. There was suspicion of a syphilitic infection on the paternal side. Separation followed shortly after the birth of the patient. The child was born a blue baby, but apparently after a few days no abnormality was noted. As long as she could remember, her vision had been much poorer than that

of other children. She remembered that after securing glasses at the age of 6 she still was unable to see the school blackboard and that a special desk was placed at the front of the room in order to aid her. Glasses were frequently changed until she was 16 years old, at which time she was told by her ophthalmologist that nothing further could be done for her vision. She then began to make the usual "rounds," encountering great disappointment in her quests for visual improvement. Eventually, she was hospitalized at Philadelphia, where the diagnosis of interstitial keratitis was offered. The etiologic factor remained unknown to the patient; however, she was referred to her family physician for biweekly intramuscular injections of arsphenamine. This treatment was continued for a long time, several separate series of injections being given. At the age of 21 a recurrence of her ocular trouble further incapacitated her. The corneas became grayish, with further visual

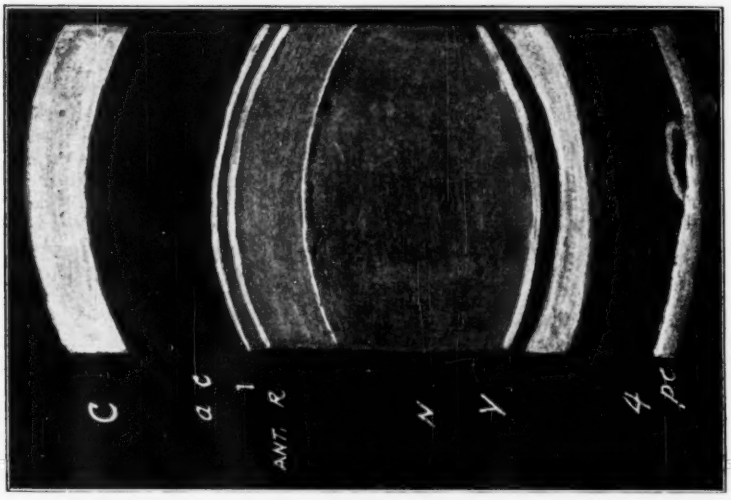

Fig. 2.—Diagram explaining figure 1: *c*, the cornea; *ac*, the anterior chamber; *1*, the anterior capsule; *ant. r*, anterior reduplication band; *N*, nucleus; *y*, yellow ring; *4*, complicated cataract, and *pc*, posterior capsule.

reduction. After she had completed the course of injections, her eyes cleared considerably. She had observed that her ocular condition became worse during such critical periods as adolescence and the menopause (following hysterectomy).

Physical examination revealed that vision in the right eye was 2/200, correctable to 20/200 with —10.00 sph. ⊃ —7.00 cyl., axis 165. Vision in the left eye was 3/200, correctable to 20/25 with —12.00 sph. ⊃ —7.50 cyl., axis 165. There was a slight suggestion of exophthalmos, the Hertel exophthalmometer reading being 21 mm. for each eye.

There was no anomaly of motility, excursions of muscles appearing normal in all the cardinal directions of gaze. The pupils reacted promptly to light and in accommodation. The cornea of the right eye showed typical *Glasleiten* bodies. For the most part, these occupied the superior temporal quadrant of the right

cornea and were arranged in the form of a delicate network. They did not extend into the anterior chamber to any degree. They were transparent and rather definitely round in cross section (Duke-Elder[3]). No such change was noted on the cornea of the left eye or over the remaining area of the right cornea. The anterior chambers were of moderate depth. The iris was not remarkable in either eye.

The anterior capsule of each lens showed an increase in the number of lenticular spherules, particularly in the lower peripheral portion. The anterior reduplication band was not unusual. No disturbance or irregularity was demonstrable between this band and the anterior capsule. A rather wide clear zone extended up to the anterior surface of the embryonal nucleus. At this surface a dense, yellowish band was discernible; this band as seen in cross section fanned out in thickness toward the periphery but completed a circle of communication with the similar, but denser, band present in the same position in the posterior portion of the lens. The area between this yellowish ring was still fairly clear in the left eye, but in the right eye its appearance was identical with that of a nuclear cataract. In the right eye the anterior and posterior Y's appeared practically normal, whereas in the left eye these landmarks seemed like black Y's in a yellowish center. In the right eye a yellowish reduplication line was present just beyond this postembryonal band, which band was slightly thicker than the line just anterior to it. It had a diagonally streaked, hatched appearance. This reduplication line could not be made out in the posterior area of the lens in the left eye. Beyond these lines the lens appeared fairly clear until just anterior to the posterior capsule in the axial region, where appeared a series of polychromatic, crumblike, lustrous bodies, more pronounced and more extensive on the left side than on the right. This complicated cataractous change did not extend very far peripherad.

When viewed by direct illumination, these changes in the lens appeared like two extremely well delineated, miniature nuclear cataracts, about 5 mm. in diameter, suspended in an area of clear cortex. The most striking feature about the opacities was the manner in which they were bordered or outlined. They looked just as though they had been suspended within a picture frame (figs. 1 and *2*).

The extreme periphery of the fundus of each eye revealed an old healed choroiditis. This peripheral annular disseminated chorioretinitis was somewhat different in the two eyes. In the right eye the changes were primarily in the temporal periphery and consisted of small round black foci with eccentric whitish centers grouped together. There were also several larger, lobulated masses with no centers. In the left eye the annular pigmentation was much less extensive and occurred in groups, with no signs of lesions with white centers. The choroidal lesions appeared characteristic of congenital syphilitic annular chorioretinitis of the grouped pigmentation type. The *Glasleiten* bodies of the right cornea also suggested a congenital syphilitic origin.

COMMENT

From a study of this isolated case, it would seem that the presence of these changes in the lens should be anticipated in cases in which annular chorioretinitis and *Glasleiten* bodies of the cornea coexist, and that it

3. Duke-Elder, W. S.: Text-Book of Ophthalmology, St. Louis, C. V. Mosby Company, 1938, vol. *2*, p. 1876.

should be considered a finding of diagnostic import. The location of this type of band within specific zones of the lens is, of course, indicative of a nutritive disturbance of the lens at a period of syphilitic recrudescence. The implication may be that of an allergic response in tissue capable in each instance of reacting in a specific way, i. e., the avascular cornea responding in one manner, as only an avascular tissue can react, and the lens being organ specific and responding as would be anticipated of a highly avascular tissue. The annular intensification band in the lens is not unlike "annular rings" elsewhere in the plant and animal kingdoms. It connotes a period of temporary arrest in growth, and its cross sectional thickness is an indication of the duration of the altered state of the reacting organism. The predilection for the posterior portion of the lens is concerned with the capsulolenticular barrier and the relative intensities of the inflammatory reactions in the anterior and posterior ocular segments. In other words, if the inflammatory process is of equal intensity in the choroid and in the cornea, the annular ring should be more pronounced in the posterior portion of the lens, for passage of noxious products through the posterior portion of the lens should be less restricted. Thus, the posterior accentuated band should be anticipated. This band may also be of diagnostic import, since the conditions which may lead to its formation are necessarily limited. This lesion, like many other lesions, is not uncommon; its recognition will go hand-in-hand with an increase in the number of cases reported.

There are two other points which this case illustrates. The method of refraction in similar cases has no relation to glasses previously worn by the patient or to the retinoscopic findings. The patient herself discovered that her vision could be improved tremendously by placing her reading glasses over her distance glasses (left eye). This correction represented approximately the following prescription:

	Right	Left
Near		
Distance	No improvement:	— 4.50 sph. ⌒ —3.50 cyl., ax 165
		— 7.50 sph. ⌒ —3.50 cyl., ax 165
		= —12.00 sph. ⌒ —7.00 cyl., ax 165;
		20/25 visual acuity

The second noteworthy point in this case is the aggravation of preexisting lenticular opacities at the time of one of the physiologic periods of stress (i. e., adolescence and the menopause). This point, of course, is well known but bears repetition, especially if presumptive evidence can be offered to establish such a claim.

Von Szily [4] has emphasized the promising opportunity of gaining a deeper insight into general pathology through observation of the changes in the lens, a structure which may be regarded as a complex group of cells forming an organ of such genetic uniformity as is found nowhere else in the body. This structure, living under such unusual conditions and composed of cells of such various ages, may show changes which bespeak alterations in body fluids at a specific time in life.

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4. von Szily, Ridley and Sorsby: Modern Trends in Ophthalmology, London, Butterworth & Company, Ltd., 1940.

VISION OF ALBINOS

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ALBINOS have been known and described as such since very early times, but, unfortunately, the condition has been considered an anthropologic and genetic problem rather than a medical one. Albinism is a complex condition which probably includes more than just a lack of pigmentation.[1] It is usually divided into complete albinism and partial albinism, often called albinoidism or leukism (Gates [2]). Complete albinism, which will be referred to simply as albinism, is a genetic recessive character, transmitted by a partially sex-linked mosaic of genes (Castle and Allen [3]). Since the condition seems to be found more commonly in men, it was thought at one time to be semifatal to women, but there is no evidence for such an assumption. Albinism is characterized by pigmentless hair, skin and eyes and by ocular defects. Ametropia, astigmatism, nystagmus, photophopia and amblyopia are almost invariably all present. With age, albinos not uncommonly acquire more pigment (Pearson, Nettleship and Usher [4]).

Albinoidism is genetically dominant and regional in character. It may be as localized as a shock of white hair or as general a condition as to be almost undetectable from albinism. Generally, the hair and skin are slightly darker and the texture of the hair is less fine than they are in complete albinism. Affected persons have photophobia but no ocular defects. Because of this absence of ocular involvement, albinoidism will not be considered in this paper.

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1. Clark (Tr. Am. Ophth. Soc. **42**:250-262, 1944) maintained that albinism is a much more widespread defect than just a lack of pigment and concomitant foveal impairment. He found that the condition may also be marked by the presence of lesions of the central nervous system. Neurologic examinations will be made on as many subjects in this series as practicable to see whether any such lesions can be detected.

2. Gates, R. R.: Human Genetics, New York, The Macmillan Company, 1946, vol. 1.

3. Castle, W. E., and Allen, G. M.: Proc. Am. Acad. Arts & Sc., vol. 38, no. 21 (April) 1903.

4. Pearson, K.; Nettleship, E., and Usher, C. H.: Monograph on Albinism in Man, London, Dulau & Company, 1911-1913, pts. 1 and 2.

Albinism seems to be a relative lack, rather than complete absence, of pigment, the variations in pigmentation being greatest in the eyes. The question how much pigment an albino may have in his eyes and where it occurs has been a highly controversial one. Duane [5] stated that the pigment of the pigment epithelium is merely scanty in albinos. Elschnig,[6] in his albinos, observed pigment in the pigment epithelium of the sphincter of the iris, the ciliary body and the retina but no pigment in the iris stroma or in the choroid. Gilbert [7] noted pigment throughout the pigment epithelium. Schanz [8] stated that in all albino eyes which had been examined, without exception, pigment had been found in the pigment epithelium, even when the other ocular parts and the rest of the body were entirely free from pigment. Neame and Williamson-Noble,[9] however, asserted that in the albino there is no pigment in the pigment epithelium. Collins and Mayou [10] stated that in the albino infant's eye there is no trace of pigment, but that in every adult albino eye thus far examined traces of pigment have been observed. Pigment has been found in the retinal epithelium when it is entirely absent from the stroma of the iris, ciliary body and choroid. Pigment may be entirely absent from the stroma of the uveal tract except in the choroid of the macular region. Gates [2] stated that in total, or complete, albinism the pigmentation of the eye varies, traces of pigment being present nearly always in some parts of the eye.

It is apparent from this review that any subject examined as an albino in a series of visual tests, such as will be described, cannot be classified as an albino until after all the tests are completed. Unless the subject has both the relative lack of pigment and the distinctive visual defects he is not albino. Relative lack of pigment alone could mean that he was albinodic, or even merely blond; the visual defects alone might be caused by other conditions.

PRESENT INVESTIGATION

In the experiments which were carried out in this study a series of 16 subjects, considered albinos, was used. The purpose of the experiments was to describe and measure the vision of these persons by as many

5. Fuchs, E.: Text-Book of Ophthalmology, authorized translation from the twelfth German edition by Alexander Duane, ed. 5, Philadelphia, J. B. Lippincott Company, 1917.

6. Elschnig, A.: Arch. f. Ophth. **84**:401-419, 1913.

7. Gilbert, W.: Arch. f. Augenh. **88**:143, 1920.

8. Schanz, F.: Am. J. Psych. Optics **4**:284, 1924.

9. Neame, H., and Williamson-Noble, F. A.: A Handbook of Ophthalmology, ed. 5, London, J. & A. Churchill, Ltd., 1944.

10. Collins, E. T., and Mayou, M. S.: Pathology and Bacteriology of the Eye, Philadelphia, P. Blakiston's Son & Company, 1925.

technics as was practicable and, if possible, to enhance their visual acuity and increase their ocular comfort.

The group was obtained with the cooperation of the New York Association for the Blind, the New York Board of Education and the New York Department of Health. The ages ranged from 7 to 45 (table 1). The testing was done at the Institute of Ophthalmology, Columbia-Presbyterian Medical Center, under the supervision of Dr. LeGrand H.

TABLE 1.—*Data on Age, Fundus, Vision and Glasses for 16 Albino Subjects*

Subject	Age, Yr.	Pigment Deficiency	Vision*		Glasses
			Right Eye	Left Eye	
1	45	Extreme	20/200 sc	20/200 sc	None
2	32	Extreme	10/200 sc	8/200 sc	None
3	30	Extreme	20/200 sc	20/200 sc	RE: +4.50 ⌒ +0.50, ax. 90 LE: +4.50 ⌒ +0.50, ax. 90
4	22	Moderate	10/200 cc	10/200 cc	RE: −14.00 ⌒ −2.00, ax. 28 LE: −14.00 ⌒ −2.00, ax. 68
5	13	Extreme	15/200 cc	20/200 cc	RE: +6.00 ⌒ +2.00, ax. 90 LE: +6.00 ⌒ +2.00, ax. 90
6	12	Extreme	20/70 cc	20/100 cc	RE: −11.00 ⌒ −3.50, ax. 180 LE: −11.00 ⌒ −3.50, ax. 180
7	12	Moderate	20/70 cc	20/100 cc	RE: +1.00 ⌒ +2.00, ax. 35 LE: +1.00 ⌒ +1.50, ax. 92
8	11	Extreme	10/200 cc	10/200 cc	RE: +0.25 ⌒ −4.50, ax. 178 LE: −0.25 ⌒ −3.25, ax. 178
9	11	Extreme	10/200 cc	10/200 cc	RE: +3.50 ⌒ +2.00, ax. 180 LE: +3.50 ⌒ +2.00, ax. 180
10	11	Mild	20/200 cc	20/200 cc	RE: +1.25 ⌒ +3.00, ax. 77 LE: +2.00 ⌒ +3.00, ax. 90
11	10	Extreme	20/200 cc	20/200 cc	RE: +1.50 ⌒ +3.00, ax. 90 LE: +1.50 ⌒ +3.00, ax. 90
12	9	Extreme	20/200 cc	20/200 cc	RE: +7.00 ⌒ +1.00, ax. 95 LE: +5.00 ⌒ +1.75, ax. 90
13	9	Extreme	10/200 cc	10/200 cc	RE: −1.50 sph. LE: −1.50 sph.
14	8	Extreme	20/200 cc	20/200 cc	RE: +0.75 sph. LE: +0.50 sph.
15	7	Extreme	15/200 cc	15/200 cc	RE: −2.50 ⌒ +4.75, ax. 105 LE: −2.50 ⌒ +5.25, ax. 77
16	7	Extreme	17/200 cc	17/200 cc	RE: −2.00 sph. LE: −1.75 sph.

* The visual acuities indicated with "sc" are without correction; those with "cc," with correction.

Hardy. Each of the 16 subjects had an examination of the fundus by one of the ophthalmologists of the Institute. Thirteen were classified as having the typical extreme lack of pigment; 2 had somewhat more pigment; and 1, a boy, had sufficient pigment in the fundus to be called blond. Since the last 3 subjects had the same kind of ocular defects as the others, however, they too were considered to be albinos in the final analysis.

The visual acuity of the 16 subjects, with correction as prescribed, ranged from 20/70 to 8/200. Measurements were made for each eye,

using Snellen charts at standard distances and with standard illumination. The average acuity was approximately 20/200 (table 1).

Fourteen of the group wore glasses for distant vision and/or reading (table 1). A number of them, mainly children, considered their glasses more a burden than an aid. Many had sunglasses for outside wear, and several had their regular glasses slightly tinted. Nine of the subjects were hypermetropic and 5 myopic. Only 3 did not have astigmatic correction. According to Pearson, Nettleship and Usher,[4] refractive errors are found more frequently in albinos than in persons with normally pigmented eyes.

Each subject was tested for color blindness using the American Optical Company's Pseudo-Isochromatic Plates, revised edition; the Farnsworth Dichotomous Test, and the Bausch & Lomb model of the Rand anomaloscope. Standard conditions and technics were used in

TABLE 2.—*Color Discrimination* of Albino Subjects*

Subject	Color Discrimination	Subject	Color Discrimination
1	Low	9	Low
2	Low	10	Deuteranomalous
3	Mild protanomalous	11	Normal
4	Normal	12	Normal
5	Low	13	Low
6	Normal	14	Normal
7	Low	15	Low
8	Low	16	Low

* Color discrimination as based on examinations with the American Optical Company Pseudo-Isochromatic Plates, revised edition; the Farnsworth Dichotomous Test, and the Bausch & Lomb model of the Rand anomaloscope.

each case. Contrary to popular belief (Crafts and others[11]), albinos cannot be classified as color blind. As shown in table 2, 5 of the subjects had normal color vision, and 9 had low discrimination owing to poor acuity (no specific color blindness errors), while 1 subject was mildly protanomalous and 1 deuteranomalous. From this it is possible to say that albinos are likely to have low color discrimination due to poor acuity but are not more likely than the normal population to be specifically color blind.

Peripheral fields were measured with the Ferree-Rand perimeter, using illumination of 7 foot candles, a preexposure card and standard gray backgrounds. Each eye was measured for each 45 degree interval with 1 degree white, red and blue stimuli. The results are summarized

11. Crafts, L.; Schneirla, T.; Robinson, E., and Gilbert, R.: Recent Experiments in Psychology, New York, McGraw-Hill Book Company, 1938.

in table 3. In each of the 15 cases in which the fields were measured, white, or form, fields were contracted temporally beyond the minimum normal limits (Ferree, Rand and Monroe [12]), and in 7 cases the fields

TABLE 3.—*Peripheral and Central Fields**

Subject	Peripheral Fields			Central Fields
	Form 1°	Red 1°	Blue 1°	
1	RE: Contracted temporally LE: Contracted	RE and LE: Contracted temporally	RE and LE: Contracted temporally	Relative scotoma 3/1,000 stimulus RE: 1.5°; LE: 1.0°
2	RE: Contracted LE: Contracted	RE and LE: Contracted temporally	RE: Contracted LE: Contracted	Relative scotoma 1/1,000 stimulus RE: 4.5°; LE: 4.0°
3	RE and LE: Contracted temporally	RE: Normal LE: Normal	RE: Normal LE: Normal	Absolute scotoma 1/1,000 stimulus RE: 1.0°; LE: 1.0°
4	RE and LE: Contracted temporally	RE: Normal LE: Contracted temporally	RE: Normal LE: Contracted temporally	Absolute scotoma 3/1,000 stimulus RE: 1.5°; LE: 1.5°
5	RE: Contracted LE: Contracted	RE: Normal LE: Contracted temporally	RE and LE: Contracted temporally	Absolute scotoma 1/1,000 stimulus RE: 2.0°; LE: 2.5°
6	RE and LE: Contracted temporally	RE: Normal LE: Normal	RE: Normal LE: Normal	Relative scotoma 1/1,000 stimulus RE: 4.0°; LE: 6.0°
7	RE and LE: Contracted temporally	RE: Normal LE: Normal	RE: Normal LE: Normal	Relative scotoma 1/1,000 stimulus RE: 2.5°; LE: 3.0°
8	RE: Contracted LE: Contracted	RE: Contracted temporally LE: Normal	RE and LE: Contracted temporally	Relative scotoma 1/1,000 stimulus RE: 6.5°; LE: 4.0°
9	RE: Contracted LE: Contracted	RE: Normal LE: Contracted temporally	RE and LE: Contracted temporally	Relative scotoma 1/1,000 stimulus RE: 3.5°; LE: 4.5°
10	RE and LE: Contracted temporally	RE: Normal LE: Normal	RE: Normal LE: Normal	Absolute scotoma 1/1,000 stimulus RE: 1.5°; LE: 1.5°
11	RE: Contracted LE: Contracted	RE: Contracted LE: Contracted	RE: Contracted LE: Contracted	Relative scotoma 1/1,000 stimulus RE: 2.0°; LE: 2.0°
12	RE: Contracted temporally LE: Contracted	.....	.....	Relative scotoma 1/1,000 stimulus RE: 1.5°; LE: 1.5°
13	RE: Contracted LE: Contracted	RE and LE: Contracted temporally	RE and LE: Contracted temporally	Relative scotoma 1/1,000 stimulus RE: 3.0°; LE: 4.0°
14	RE: Contracted LE: Contracted temporally	RE: Contracted temporally LE: Normal	RE: Normal LE: Normal	Relative scotoma 1/1,000 stimulus RE: 5.5°; LE: 6.5°
15	RE: Contracted LE: Contracted	.....	.....	Relative scotoma 1/1,000 stimulus RE: 4.0°; LE: 4.0°
16	.....	.....	.....	Relative scotoma 1/1,000 stimulus RE: 3.0°; LE: 2.0°

* Peripheral and central fields as measured with the Ferree-Rand perimeter and the black meter tangent screen.

(both eyes) were contracted in all directions. Using the 1 degree red stimulus, the fields for 13 subjects were measured. Nine had contraction of at least one of their fields, either temporally or in all directions, while

12. Ferree, C. E.; Rand, G., and Monroe, M. M.: Diagnostic Scales for One Degree and 0.17 Degree Form Field Stimuli for Eight Principal Meridional Quadrants Taken Separately, Arch. Ophth. **6**:518-535 (Oct.) 1931.

4 had fields (both eyes) as large as or larger than the minimum normal (Ferree, Rand and Monroe [13]). With the 1 degree blue stimulus, 8 of the same group had at least one of their fields contracted, either temporally or in all directions, while 5 had fields (both eyes) as large as or larger than the minimum normal. The only prediction from these data is that the form fields of albinos will be contracted, at least temporally.

It was most important during this perimetric work to watch the eyes of the subject continually because of the ever present nystagmus. It was not possible to eliminate the slight oscillation, but with frequent rest periods or, in the case of some of the younger children, by snapping the fingers in front of the fixation point, it was possible with repeated trials to obtain values which did not represent gross ocular movement. Since the oscillation could tend only to increase the fields as measured, it is thought that the values given err only in the direction of being too large.

Using a black meter tangent screen with a 1 mm. white stimulus (3 mm. in 2 cases), under illumination of 10 foot candles, the central fields were measured. As is shown in table 3, in every case there was a central scotoma, being relative in 12 cases (the test object became "smaller" or "dimmer") and absolute in 4 cases (the test object, in the last 2 cases a 3 mm. test object, disappeared). Subjects were not given any clue as to what would happen to the test object but were asked merely to tell what became of it. The sizes of the scotoma ranged from 1 to 6.5 degrees and were readily reproducible.

The amblyopia, or dimness of vision of albinism is probably due almost entirely to this central scotoma. Just why the central region should be more affected by the albinism than the other regions is not known. Neame and Williamson-Noble [9] called the condition impaired differentiation of the fovea. If it were that alone, it would seem that the fovea would have the same sensitivity as the surrounding area, rather than less sensitivity. A possible explanation might be that the albino infant is born with a normal fovea, but that the fovea atrophies because of overstimulation, the pigment being insufficient to control the entering light. According to Nettleship,[14] blindness due to overexposure to bright light is always localized to the macular region. If this is the case, it might be advisable to keep albino infants away from bright light until their eyes can be protected by one of the methods to be described later.

13. Ferree, C. E.; Rand, G., and Monroe, M. M.: Am. J. Ophth. **16** (July) 1933.

14. Nettleship, E.: Diseases of the Eye, New York, Lea Brothers, 1900.

It was suggested by Wölfflin [15] in 1905 that the speed of dark adaptation may depend partially on the amount of pigment in the retina. Schirmer,[16] however, in 1890 had reported finding normal adaptation in 4 albinos, the Forster photometer being use for measurement. Stargardt [17] (1910), Mosso [18] (1914) and Takagi [19] (1926) also reported normal adaptation for albinos, although they did not use light adaptation before the measurements or use normal controls. Shaad [20] (1933) measured a group of 10 albinos and 13 persons with normal pigmentation, using the Nagel adaptometer, with preexposure to an illuminated screen (18.95 millilamberts) for five minutes. She took readings for each eye at one, five, ten, twenty and thirty minutes. Averaging the curves for the albino subjects and those for the normal subjects, she concluded that albinos adapt more slowly at first but become somewhat more sensitive by the end of the thirty minutes than do the normal subjects. Since she used a small group and took only five readings per eye, it is felt that her average curve for albino subjects cannot be considered as significantly different from the curve for normal subjects. Bunge and Heyn [21] (1938) measured the dark adaptation of 8 subjects with general albinism and 1 albinodic subject (in the latter the eyes were pigmentless, but not the body). The authors permitted light adaptation for fifteen minutes; they then took readings with the Engelking-Hartung adaptometer every minute for the first few minutes, and then every five to ten minutes up to forty-five minutes. They found both photopic and scotopic curves normal for all the subjects.

In the current study, dark adaptation was measured with the Hecht-Shlaer adaptometer under standard conditions for each eye of 13 subjects and for one eye of 2 subjects. In the case of a 7 year old subject it was impossible to measure dark adaptation. Readings were taken at approximately one minute intervals for thirty minutes. For 5 subjects the dark adaptation was normal (Mandelbaum [22]); for 5 the curves were somewhat irregular, with the final thresholds normal. For the other 5 subjects the final thresholds were from 0.1 to 0.5 log micromicrolamberts high

15. Wölfflin, E.: Arch. f. Ophth. **61**:524, 1905.

16. Schirmer, O.: Arch. f. Ophth. **36**:121, 1890.

17. Stargardt, K.: Arch. f. Ophth. **73**:77, 1910.

18. Mosso, G.: Ann. di ottal. **43**:79, 1914.

19. Tagaki, R.: Ztschr. f. Augenh. **58**:436, 1926.

20. Shaad, D. J.: Dark Adaptation in Albinotic Eye, Arch. Ophth. **9**:179-190 (Feb.) 1933.

21. Bunge, E., and Heyn, W.: Klin. Monatsbl. f. Augenh. **100**:178-186 (Feb.) 1938.

22. Mandelbaum, J.: Dark Adaptation: Some Physiologic Considerations, Arch. Ophth. **26**:203 (Aug.) 1941.

(table 4). From these results, which agree for the most part with the previous work, it can be said that albinos have fairly normal adaptation, with both rods and cones functioning properly.

Nystagmus seems to be ever present in albinos. According to Pearson, Nettleship and Usher,[4] the nystagmus associated with albinism is no different from that caused by other deficiencies, abnormalities or diseases of the eye. Poor central vision, caused in this case by the amblyopia and/or central scotoma, allows the subcortical rhythm center, which is normally held in check by the cortex, to produce the involuntary rhythmic oscillations (Lorente de Nó and Berens [23]).

TABLE 4.—*Dark Adaptation* in 16 Albino Subjects*

Subject	Normal Adaptation	Normal Atypical	Typical Shape Final Threshold High	Atypical Shape Final Threshold High
1	Right and left eyes	.....	.....	.....
2	Right and left eyes	.....	.....	.....
3	.....	.....	Right and left eyes	.....
4	.....	Right and left eyes	.....	.....
5	.....	Right and left eyes	.....	.....
6	.....	.....	.....	Right and left eyes
7	.....	Right and left eyes	.....	.....
8	.....	Left eye	.....	.....
9	.....	.....	.....	Right and left eyes
10	Right and left eyes	.....	.....	.....
11	Right and left eyes	.....	.....	.....
12	.....	.....	.....	Right and left eyes
13	Right and left eyes	.....	.....	.....
14	.....	Right and left eyes	.....	.....
15	.....	.....	.....	.....
16	.....	.....	.....	Left eye

* Dark adaptation, as measured by the Hecht-Shlaer Dark Adaptometer, using standard conditions and technics.

Usher (Pearson, Nettleship and Usher [4]) observed the frequency of nystagmus movements in 33 albinos. For 7 it was within the range of from 66 to 96 movements per minute; for 17, from 100 to 120 per minute, and for 9, from 121 to 156 per minute.

The nystagmus of a group of albino subjects was reported on by Ohm.[24] Over a period of years, he had measured the nystagmus of 31 subjects with pigmentless or defectively pigmented retinas. His

23. Lorente de Nó, R., and Berens, C.: Nystagmus, in Piersol, G. M.; Bortz, E. L., and others: The Cyclopedia of Medicine, Surgery, and Specialties, Philadelphia, F. H. Davis Company, 1939.

24. Ohm, J.: Arch. f. Augenh. **103**:216-235 (June) 1930.

method, which he used in all his work on nystagmus (Ohm [25]), consisted in recording on a kymograph the movements of the eye by means of a fixed system, attached by a hook and string to the edge of the cornea. In all subjects he found uniformity in the direction of the movement, being horizontal in 27 and rotary in 4. There was, however, great lability in frequency and amplitude. Frequencies for the group ranged from 0.6 to 9.7 movements per second, and amplitudes, from 0.1 to 6.0 mm. Certain special conditions modified the movement. In general, looking to the left caused quick movements, or "rucks," to the left, with slower return movements; looking to the right caused the reverse. Looking straight ahead gave "dome"-shaped and "inverted dome"–shaped movements. In the light the nystagmus was more pronounced than in the dark.

This method has several sources of error. A weighted lever system is apt to give a distorted record, with lagging and overshooting. The trauma of attaching a hook to the edge of the cornea is likely to affect the results. Reliance solely on a Zeiss chin rest to immobilize the movements of the head is far from satisfactory.[26]

The nystagmus of the albinos in this study was described on the basis of observtions and motion pictures taken at 10 frames per second with the use of infra-red illumination. Since the nystagmus was observed to have little, if any, vertical component in any of the subjects, only the horizontal component was measured, although the photographic records could be used to measure the vertical component as well.

The motion pictures of the nystagmus were made utilizing equipment designed for work in pupillography (Löwenstein and Friedman [27]). During the photographing (in a darkened room, with only infra-red light), the subject was told to look in the direction of a faintly lighted ground glass prism, 1 by 1.2 cm., at a distance of 30 cm., without attempting to focus or strain. The head was held by head and chin rests. Further to insure immobilization of the head, a tiny point of light was directed on a spot of ink dabbed on the nose. So long as the point of

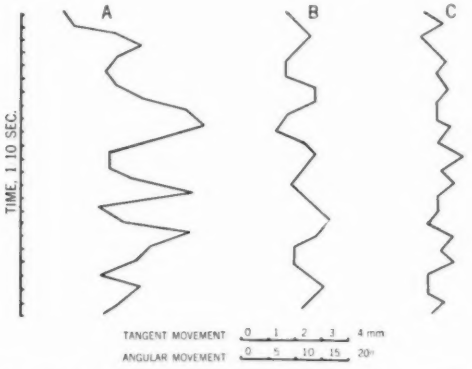
25. Ohm, J.: Klin. Wchnschr. **4**:1286, 1925.

26. Adler and Fliegelman (Influence of Fixation on Visual Acuity, Arch. Ophth. **12**:475 [Oct.] 1934) measured ocular movements using a tiny mirror attached to the temporal limbus. The beam of light reflected by the mirror was recorded photographically. This method is simple and seems superior to Ohm's but still has the factor of a foreign body on the eye.

27. Löwenstein, O., and Friedman, E. D.: Pupillographic Studies: Present State of Pupillography; Its Method and Diagnostic Significance, Arch. Ophth. **27**:969 (May) 1942.

light remained fixed on the spot, it was assumed that the head was not being moved.

The nystagmus was measured (horizontal component) by projecting the developed film on a calibrated screen and plotting the position of the center of the pupil against time. In this way, movement of the pupil as projected on a line tangent to the vertex of the cornea was recorded. The optical system was such that the projected eyes were ten times normal size. Movement measured in centimeters on the screen could then be plotted as millimeters on the graph. Because of the impracticability of determining the straight-ahead position of the eyes, an arbitrary position was chosen in each case, and the relative movements were then plotted. Using Helmholtz' value for the average radius of the globe,



Short sections of graphs showing horizontal nystagmus movements as measured photographically with infra-red light. See text.

A (subject 15) is the graph for marked nystagmus; B (subject 12), for moderate nystagmus, and *C* (subject 5), for slight nystagmus. Comparative scales for tangent and angular movements appear below the graphs.

11.025 mm. (Helmholtz [28]), this tangent movement can be converted into angles of ocular rotation, 1 mm. very nearly equaling 5 degrees in the ranges used. Portions of typical graphs with scales for tangent movement and angular movement are given in the figure.

From the graphs made for the group, the maximum and average movements and the frequency for each subject were determined. (Voluntary movements, whenever present, could be distinguished by their

28. Helmholtz, H. L. F.: Treatise on Physiological Optics, ed. 3, translated from the German by J. P. C. Southall, Menasha, Wis., G. Banta Publishing Company, 1924, vol. 3.

amplitude and nonrhythmic occurrence.) The frequencies of the group ranged from 35 to 220 per minute. The maximum movements were as great as 9.5 mm. and as slight as 0.5 mm. The average movements ranged from 5 to 0.5 mm. (table 5). These values agree fairly well with Ohm's findings. From the size of the average movement it is possible to classify the nystagmus as marked, moderate or slight. It might be said that if the average movement is 1 mm. or less the nystagmus is slight; if less than 3 mm. but more than 1 mm., it is moderate; if 3 mm. or more, it is marked. In this group, then, there were 3 subjects with marked nystagmus, 3 with moderate nystagmus and 9 with slight

TABLE 5.—*Nystagmus in 16 Albino Subjects* *

Subject	Direction	Frequency, Min.	Maximum, Min.	Average, Min.	Amount	Awareness	Effect of Concentration on Movement
1	Horizontal	75	3	1.5	Moderate	No	Increased
2	Horizontal	220	2	1	Slight	No	Increased
3	Horizontal	180	3	1.5	Moderate	No	Increased
4	Horizontal	220	2	1	Slight	Yes	Increased
5	Horizontal	170	1.5	1	Slight	No	Increased
6	Horizontal	35	0.5	0.5	Slight	No	Increased
7	Horizontal	110	1	0.5	Slight	Yes	Increased
8	Horizontal	105	1.5	1	Slight	Yes	Increased
9	Horizontal	60	9.5	5	Marked	No	Increased
10	Horizontal	100	6.5	3	Marked	Yes	Increased
11	Horizontal	140	3	1	Slight	No	Increased
12	Horizontal	130	2.5	1.5	Moderate	Yes	Increased
13	Horizontal	110	2	1	Slight	No	Increased
14	Horizontal	120	1.5	1	Slight	No	Increased
15	Horizontal	120	5	3.5	Marked	Yes	Increased
16	Horizontal	...	..	..	.....	No	Increased

* The nystagmus in the dark as measured photographically using infra-red light, with the subjects looking straight ahead but not fixating.

nystagmus. These values are for a darkened room only, with the subject looking straight ahead without straining or focusing. As is shown in table 5, concentration on an object at close (reading) distance increased the nystagmus for every member of this group.

By observation and questioning, it was possible to determine whether or not the subjects were aware of their nystagmus. Ten were not aware of the movement, while 6 were. Of the 6, 1, a girl, was able to modify, i. e., partially control, her nystagmus for very short intervals. I had previously noted this modifiability in another albino, and it seemed not to be correlated with either amount or frequency of movement.

Since albinos have little or no pigment in the sclera or the epithelium of the iris (or in the fundus), light enters through any part of the front of the eye, rather than through the pupil only, as in normally pigmented eyes. This diffuse light blurs the image formed by the light passing through the pupil and causes great discomfort in high illumination. It is typical of albinos to squint and shade their eyes in the

sunshine or in a brightly lighted room. Sunglasses serve only to reduce the total illumination falling on the eye, and when dark enough to reduce the squinting effectively, they reduce the already extremely low acuity. Pinhole goggles are not successful, since the subjects, with their ever present nystagmus, are unable to look through the aperture.

Several technics have been devised in the past in an effort to improve the vision of albinos by the removal of glare while not reducing the acuity. Kreiker [29] attempted to dye the tarsal conjunctiva with gold chloride. While theoretically sound, the darkened lid allowing less light to reach the globe, the results were unsatisfactory. The dye brought about a serious inflammatory reaction, with consequent sloughing off of necrotic tissue and scarring. Furthermore, the dye disappeared from the area in several weeks. Ascher,[30] in 1930, suggested that, rather than the method of tattooing the periphery of the cornea, the wearing of contact lenses with an opaque sclera and iris might be effective. Müller of Wiesbaden made two experimental lenses, but there seems to be no report of any one actually trying to wear them. Streiff [31] made improvements on the Müller contact lenses and in 1 case, using one lens, found vision improved. Friede,[32] after attempting to dye both the conjunctiva and the sclera, obtained more satisfactory results in slitting the eyelids and implanting pigmented paraffin.

Great progress has been made in the past few years in the design and manufacture of contact lenses, and it was felt that a new attempt with a larger group of albinos was in order. Contact lenses have the advantage over lid pigmentation methods in that use of a smaller aperture, the size and shape of the pupil, is possible. Then, too, no surgical intervention is required. Since the lenses move with the eyes, nystagmus does not defeat their purpose, as it does for the pinhole goggles. The cosmetic effect of the contact lenses, if they are properly painted, can be extremely good.

Special sets of contact lenses with an opaque sclera and iris were made up for the group. It was hoped that they would enhance the vision of albinos, or at least give them greater comfort in high illumination. The test sets had a white sclera, a dark blue iris and a 3 mm. pupil. Of the 13 albinos who were willing to try the special lenses,

29. Kreiker, A.: Klin. Monatsbl. f. Augenh. **77**:109-112 (Dec.) 1926.

30. Ascher, K. W.: Klin. Monatsbl. f. Augenh. **85**:829 (Dec.) 1930.

31. Streiff, J.: Klin. Monatsbl. f. Augenh. **89**:625-628 (Nov.) 1932.

32. Friede, R.: Klin. Monatsbl. f. Augenh. **77**:113-123 (Dec.) 1926; ibid. **85**:186-194 (Aug.) 1930; Wien. med. Wchnschr. **97**:159-160 (March) 1947.

12 were able to tolerate them (table 6). After the lenses were put on, each subject had refraction, standard test lenses being used. (Individual prescriptions can, of course, be ground in.) The acuity was then retested, using standard procedure, and the subject was afterward taken into bright daylight for his subjective feelings. Of the 12, 8 had their visual acuity enhanced over and above that with regular glasses—in 1 case from 10/200 to 10/70. The other 4 subjects had no measurable increase in acuity. The 8 with the enhanced acuity and 2 of the others felt much more comfortable in the high illumination and ceased to squint. The remaining 2 subjects (the oldest and the youngest) had no appre-

TABLE 6.—*Results with Special Contact Lenses* on Vision in Albinos*

Subject	Tolerance	Visual Acuity	Strong Illumination
1	Good	RE: 10/70 LE: 10/70	Slight benefit
2	Not tolerated	.....	.....
3	Good	Same as with correction	Greater comfort
4	Good	Same as with correction	Greater comfort
5	Good	RE: 10/70 LE: 10/70	Greater comfort
6	Good	Same as with correction	Greater comfort
7	Good	Same as with correction	Greater comfort
8	Good	RE: 10/100 LE: 10/100	Greater comfort
9	Good	RE: 10/100 LE: 10/100	Greater comfort
10	.....	.....	.....
11	Good	RE: 10/70 LE: 10/70	Greater comfort
12	Good	RE: 10/70 LE: 10/70	Greater comfort
13	Good	RE: 10/70 LE: 10/70	Greater comfort
14	.....	.....	.....
15	Good	RE: 10/100 LE: 10/100	No benefit
16	.....	.....	.....

* The contact lenses had an opaque white sclera and an opaque blue iris.

ciable increase in visual acuity or ocular comfort. It is felt that for the majority of albinos these special contact lenses would be of value.

SUMMARY

Complete albinism, a genetic recessive trait, is a relative lack of pigment. Ocular defects are always present. The lack of pigment causes the photophobia, while the amblyopia and nystagmus are due to the defective foveal region. Astigmatism and ametropia, while not directly related to the albinism, are correlated with it.

Albinism does not cause color blindness, although the poor acuity often results in low color discrimination. Form fields are likely to be somewhat contracted. Dark adaptation is fairly normal.

The simplest and most practical means of enhancing vision in albinos is probably through the use of contact lenses with opaque iris and sclera.

Columbia University College of Physicians and Surgeons.

OPTIC NEUROENCEPHALOMYELOPATHY (DEVIC'S DISEASE)

Report of a Case

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AND
LARRY L. CALKINS, M.D.
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THE PURPOSE of this report is to present the clinical findings in a typical case of optic neuroencephalomyelopathy (neuromyelitis optica) with corroborative pathologic studies. This syndrome was first described by Allbutt [1] in 1870 but was so well summarized and analyzed by Devic [2] in 1894 that it is usually associated with his name. It consists of bilateral optic or retrobulbar neuritis and ascending myelitis manifested by paraplegia of the upper motor neuron type, which is commonly preceded by sensory disturbances. As pointed out in the standard textbooks of neurology and in a recent and excellent review of the literature by Silbermann,[3] this condition must be differentiated from the more acute encephalomyelitis arising spontaneously or after acute infections, from encephalitis periaxialis diffusa (Schilder's disease), which occurs in infancy and in childhood, and from the more chronic and relapsing multiple sclerosis.

Often called diffuse myelitis with optic neuritis, neuromyelitis optica, ophthalmoneuromyelities or Devic's disease, it is defined pathologically as, "a form of subacute encephalo-myelitis characterized by massive demyelinization of the optic nerves and spinal cord sometimes running a self limited and sometimes a progressive course."[4] The etiology is unknown.

REPORT OF A CASE

J. L., a white man aged 45, was admitted to the ophthalmology service of the Hospital of the University of Pennsylvania on March 5, 1947, because of complete loss of vision. He first noted dimness of vision in both eyes on February 20, one week after a moderately severe, self-treated infection of the upper

From the Department of Ophthalmology, Hospital of the University of Pennsylvania.

1. Allbutt, T. G.: On the Ophthalmoscopic Signs in Spinal Disease, Lancet **1**:76, 1870.

2. Devic, M. E.: Myelite aiguë dorso-lombaire avec névrite optique, Cong. franç. de med. **1**:434, 1894.

3. Silbermann, S. J.: Devic's Disease, J. Nerv. & Ment. Dis. **102**:107, 1945.

4. Brain, W. R.: Diseases of the Nervous System, ed. 3, London, Oxford University Press, 1947.

respiratory tract. By February 25, on his admission to another hospital, he was totally blind. Ophthalmoscopic examination at that time revealed 2 D. of papilledema bilaterally, accompanied with numerous linear hemorrhages at the disk margins. A tentative diagnosis of intracranial neoplasm or cerebral abscess was made, and transfer was made to the Hospital of the University of Pennsylvania for further diagnostic facilities.

At the time of his admission to this hospital, throbbing frontal headache and numbness of the right leg had developed. He had no light perception in either eye. The lids, palpebral fissures and lacrimal apparatus were normal. Corneal sensitivity was not diminished. The pupils were semidilated and fixed to light. The left was slightly larger than the right. They constricted slightly on convergence and forced closure of the lids. Examination with the slit lamp showed minimal, senile, cortical cataractous changes in each lens.

Ophthalmoscopic examination showed clear media in each eye. The margin of each optic nerve head was blurred. Each disk was elevated 3 D., and there

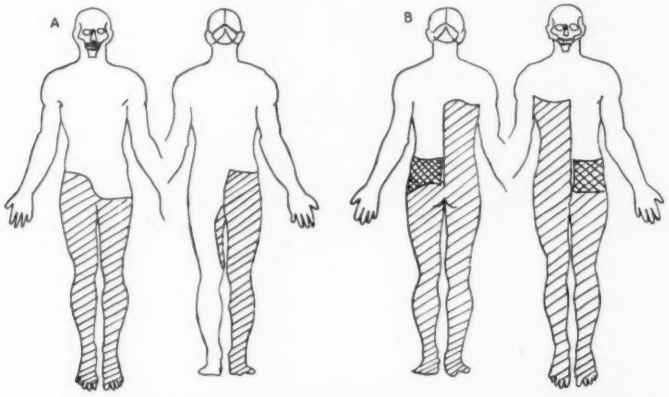

Fig. 1.—*A* (March 5, 1947), sensory loss to pinprick; *B* (March 9), sensory loss to touch, pain and temperature stimuli (single hatchure) and hyperesthesia to thermal stimuli (double hatchure).

was definite edema of the retina adjacent to the nerve head. Numerous hemorrhages and exudates were present on and near each optic nerve. The veins were moderately distended and slightly tortuous. The light reflexes of the retinal arteries were increased, and there were arteriovenous crossing defects near the disk.

Neurologic examination showed that all the cranial nerves except the second were intact. No pathologic reflexes were elicited. There was sensory loss to pinprick over both lower extremities, more pronounced on the right and extending to the crest of the ilium (fig. 1 *A*). The tentative diagnosis was optic neuroencephalomyelopathy; other neurologic lesions had to be excluded.

The results of initial laboratory studies were normal, and on March 7, when motor weakness appeared in the lower extremities and the left arm, a lumbar puncture was performed under manometric control. The initial pressure was 70 mm. of water, and the cell count and protein estimation were within normal limits. Complete

roentgenographic examinations of the skull and chest revealed nothing abnormal. On March 9, the fourth day of hospitalization and the date of his transfer to the neurologic service, the patient exhibited increased motor disturbance and sensory loss. Deep touch, pain and temperature sensibility was lost below the sixth thoracic dermatome on the right and the first lumbar dermatome on the left. There was an area of hyperesthesia to cold on the left extending from the first lumbar to the ninth thoracic dermatome (fig. 1*B*). Difficulty in voiding, requiring catheterization, was noted at this time. A urethral stricture was found, and a catheter was left indwelling. By March 11, the Babinski sign was definitely positive on the left, and the temperature rose to 102 F., with spiking to 105 F. in eight hours. This elevation was thought to be urethral in origin. On March 13, eight days after his admission, some strength returned to the left arm and leg, and the patient was able to perceive bright light in the right eye. By March 15 he could tell the shapes of attendants, and two days later he could count fingers. On March 20 he was paralyzed in both legs and had severe abdominal distention. Within the next forty-eight hours, he had light perception in the left eye, and the sensory level was 3 cm. above the nipple line on the left and at the iliac crest on the right. On March 23, weakness in the arms was complete, and he first noted difficulty in swallowing. There was greater difficulty in breathing, and he was placed in a respirator. The force of cough was decreased, and a toothache type of pain, formerly present in the neck and arm, disappeared. Vision improved on the right so that objects were recognized. On March 27, he was unable to be out of the respirator; dulness of sensibility to pinpoint developed over the left side of the face, and he complained of deafness of the left ear. Vision continued to improve, and prompt pupillary reactions were present in both eyes. On March 28 he had a temporary episode of unconsciousness and a period of delirium, followed by death in a few hours, slightly more than five weeks after the onset of symptoms.

Cultures of the spinal fluid during the clinical course of the disease and of the spinal fluid and tissue of the central nervous system obtained at necropsy failed consistently to yield any pathogenic bacterium or virus.[5]

OPHTHALMOLOGIC AND NEUROPATHOLOGIC REPORT

Gross Description.—The right eye measured 24 by 23 by 23 mm. and appeared normal on transillumination. Oblique section revealed no abnormality. Cross section of the optic nerve revealed that the internal markings were indistinct. There was noticeable softening of the nerve, particularly just in front of the chiasm.

The left eye measured 24 by 24 by 22 mm. Transillumination revealed no shadow. Oblique section revealed nothing significant. Cross section of the left optic nerve resembled that of the right.

The brain showed widening of the sulci over the frontal lobe. The vessels of the surface were congested. The brain as a whole felt uniformly firm. The base of the brain, the brain stem and the cerebellum were normal in appearance.

In cross section the ventricles were of normal size and shape. There were oval and irregular areas of gelatinous softening in the white matter of the left parietal lobe. Gross section of the cerebellum showed nothing abnormal. The meninges were not grossly changed. The appearance of the spinal cord and the cauda equina was normal. Sections of the spinal cord showed some loss of normal configuration and disturbance of internal markings.

5. Studies were carried out by Dr. Werner Henle in the bacteriology and virus laboratories of the Children's Hospital of Philadelphia.

Microscopic Description.—Pathologic material was fixed in dilute solution of formaldehyde U. S. P. (1:4) and was prepared in Müller's fluid as seemed indicated. All levels of the brain and spinal cord were studied with the standard hematoxylin and eosin stain. The general topographic pattern was followed in sections stained by the Weigert method. Cell aggregations were identified by the Nissl technic (toluidine blue). Some myelin degenerations were followed by treatment with osmium tetroxide, after the technic of Marchi. Silver staining was used as needed.

Eyes: Because of the meager knowledge of the nature of this disease, the eyes were not sent to the Eye Bank for Sight Restoration, but were submitted to pathologic examination.

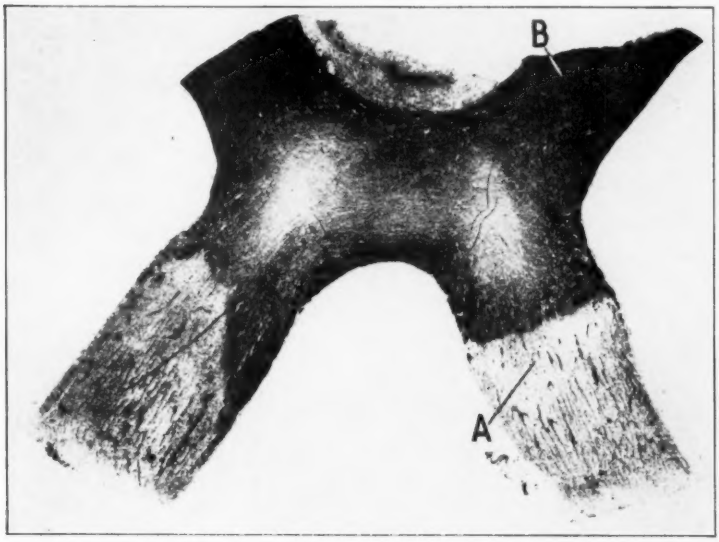

Fig. 2.—Optic chiasm showing demyelination of the optic nerves (*A*). The optic tracts are not involved (*B*). × 8.

The changes in the right eye were limited primarily to the optic disk and nerve. The optic nerve showed almost complete demyelination to a point just proximal to the chiasm (fig. 2). Feeble glial proliferation was observed to be more pronounced nearer the eye. In the demyelinated areas compound granular corpuscles were seen, and variable amounts of lymphocytic infiltration occurred, occasionally showing accumulation about the central vessels. No hemorrhage was noted. In a small area just distal to the lamina cribrosa myelin sheathing was retained (fig. 3*A*). The left eye was similar to the right except that there was less retention of myelin and status spongiosus occurred nearer the disk (fig. 4). Both disks showed minimal papillitis (fig. 3*B*).

Spinal Cord and Brain Stem: Sections were taken from the cervical, mid-thoracic and lumbosacral areas.

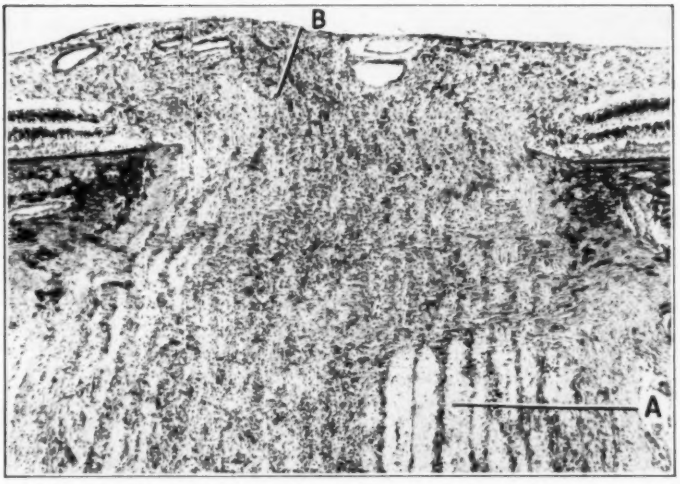

Fig. 3.—Section of the optic disk of the right eye, showing area of retained myelin (*A*), × 80, and papillitis (*B*), × 55.

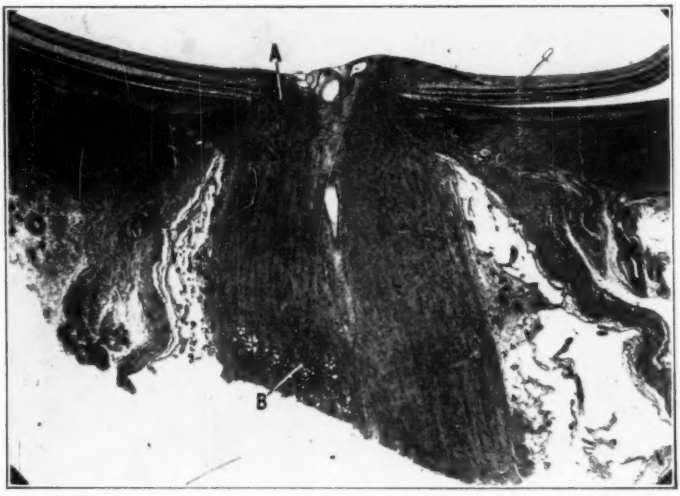

Fig. 4.—Section of the left optic nerve and disk, showing area of status spongiosus (*B*) and low grade papillitis (*A*). × 16.

Fig. 5.—Section of the cervical portion of the spinal cord (× 8). Note particularly the changes around the periphery of the section.

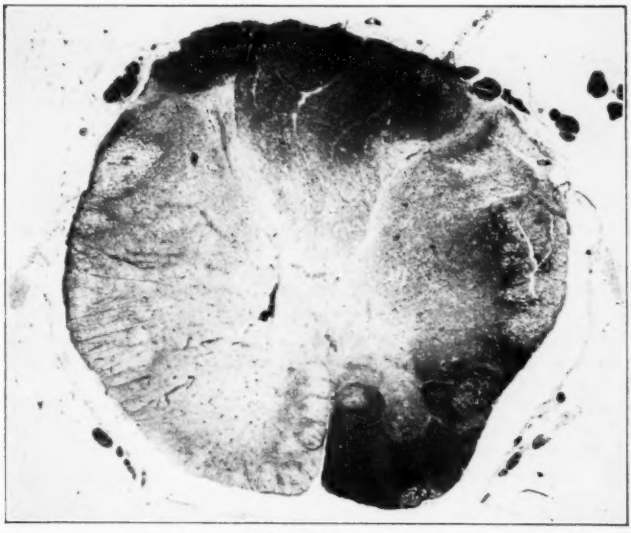

Fig. 6.—Section of the cervical portion of the spinal cord (× 9), showing an area of intense reaction where axis-cylinders are destroyed and cellular infiltration is most pronounced.

The lumbosacral sections showed diffuse demyelination of the posterior columns, with associated edema. There was no cellular activity in the area of demyelination, and the anterior horn cells stained normally.

Sections from the midthoracic region showed diffuse and irregular areas of demyelination, a major portion occurring around the periphery (fig. 5). One anterior column was more severely involved than the other. Status spongiosus was present in the areas of severe demyelination. Only occasional areas showed destruction of axis-cylinders, and here the cellular infiltration with lymphocytes was most intense. There was marked chromatolysis of the anterior horn cells. The meninges were not changed (fig. 6).

Sections through the high cervical portion of the cord and the lower portion of the medulla showed diffuse demyelination and areas of status spongiosus next to intact axis-cylinders and unchanged myelin sheaths. There was intense cellular

Fig. 7.—Section of the parietal cortex and subcortical white matter on the left side (× 5), showing focal area of demyelination (*A*) and cortex (*B*).

infiltration, consisting of lymphocytes and compound granular corpuscles. The anterior horn cells were only partly preserved. The meninges were not involved.

Sections through the medulla showed patchy areas of demyelination, the loss of myelin being mild and associated with simple edema. The ganglion cells were well preserved, and the meninges were spared.

Sections through the medulla in the area of the inferior olivary nuclei and the pons showed no change. Portions of the cerebellar cortex included in these sections appeared normal.

Sections of the diencephalon in the region of the anterior commissure showed sparing of this area.

Cerebral Cortex: Sections of the left parietal lobe (fig. 7) showed an irregular area of demyelination in the subcortical white matter; the lesion was well

delimited but was filled with many cells, most of which were compound granular corpuscles. Lymphocytes and plasma cells were occasionally seen. Coagulation necrosis was present centrally, and some of the surrounding blood vessels showed cuffs of lymphocytes. The meninges were not involved.

COMMENT

The profound temporary visual depression seen clinically in this case was correlated with severe demyelination in both optic nerves, the nearer the chiasm, the more pronounced the loss of myelin. This visual depression was thought to be secondary to the associated edema and toxemia from products of myelin degeneration. The failure to demonstrate interruption in the continuity of the axis-cylinders in severely damaged areas of the visual pathways is instructive in the light of the gradual return of vision in both eyes. The visual improvement was much more rapid after a period of hyperpyrexia of urethral origin, and there was an associated temporary lag in the ascent of the myelitis. The cervical portion of the cord in particular did show degeneration of axis-cylinders and anterior horn cells; this change was related to the clinical loss of many sensory modalities and the development of motor palsies.

The relatively afebrile clinical course and the feeble cellular response in the blood and the spinal fluid, as well as in sections of the central nervous system, are in accord with the experience of other investigators and are related to the failure to find a pathogenic bacterium or virus.

SUMMARY

A case of clinically typical optic neuroencephalomyelopathy (Devic's disease) is reported. Attempts to isolate an etiologic agent in this case were unsuccessful.

Pathologic studies showed demyelination of the optic nerves, the spinal cord and the subcortical white matter.

Hospital of the University of Pennsylvania.

KERATOPLASTY IN TREATMENT OF KERATOCONUS

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NEW YORK

KERATOCONUS is a localized conus-shaped, or mound-shaped, noninflammatory ectasia of the central portion of the cornea. The protruding area generally extends over the central half of the cornea and is always thinner than normal, but in some instances the conus may be eccentric. In some cases the deformity, after beginning to develop, remains stationary, without tendency to become worse; this condition is designated as abortive keratoconus. In other cases it remains stationary after developing to a more advanced stage; the patient is still able to obtain fairly good vision with the aid of ordinary glasses, although this correction may require the use of high cylinders.

The cornea of the conus may be reduced to one fifth of its normal thickness and in extreme cases may become still thinner. Occasionally Descemet's membrane and its endothelial lining rupture, and the aqueous passes into the parenchyma of the cornea with the subsequent development of corneal edema or hydrops. When this occurs, the protrusion increases. The apex or the whole conus becomes turbid and the condition is made worse, until the endothelium regenerates and the acute ectasia clears up, either spontaneously or with the aid of pressure dressings, often with residual permanent scarring of the apex of the conus. In other cases of keratoconus there is gradual deterioration of the deformity, generally with progressive scarring of the apex, without the occurrence of acute edema. In some extreme cases the cornea is so thin that it perforates, either spontaneously or as a result of minor trauma, with the subsequent collapse of the anterior chamber.

Until the advent of the contact lens, patients with advanced keratoconus—who could no longer obtain useful vision with the use of ordinary glasses—had to remain in a nearly blind state or submit to surgical procedures.

REVIEW OF THE LITERATURE

A review of the literature on the surgical treatment of keratoconus reveals a formidable number and variety of surgical procedures advocated for the alleviation of this disorder.

From the Institute of Ophthalmology, Columbia-Presbyterian Medical Center.

Read at the Eighty-Fourth Annual Meeting of the American Ophthalmological Society, Hot Springs, Va., May 17, 1948.

The first surgical procedure for the cure of keratoconus was that of Ware,[1] who in 1810 advocated paracentesis of the anterior chamber, followed by moderate pressure to prevent the return of the protrusion. The same procedure was recommended by Dix[2] and Desmarres d'Evreaux[3] in 1847 and by Bell[4] in 1785. Adams[1] in 1817 advocated needling of the lens in order that the increased refractive error produced by the deformity of the cornea might be neutralized. Middlemore[5] in 1835 and Tyrell[6] in 1840 proposed moving the pupil from behind the most altered portion of the cornea. The operation consisted in incarcerating the iris in a corneal opening made near the limbus. In 1839 Favio[7] resorted to the removal of a V-shaped flap, at the apex of the cone, without the application of sutures. In 1858 Critchett[2] modified the operation of Middlemore and Tyrell by tying a single knot in the prolapsed iris with a fine silk thread. The strangulated portion of the iris fell off in about forty-eight hours, and the iris remained incarcerated in the corneal cicatrix. The procedure, named iridodesis by the author, left the pupil in the desired position for obtaining the most useful vision. Bowman[8] in 1859 resorted to the practice of double iridodesis. Having observed that vision in keratoconus improved frequently with the use of a stenopeic slit, he incarcerated the pupillary borders twice, near the limbus, at opposite ends of the same diameter. The result was the formation of a slitlike pupil which could be placed in any desired direction across the cornea; Bowman, however, expressed the belief that the vertically placed pupil was to be preferred. In 1866 von Graefe[9] recommended the dissection of the superficial layers of the cone with a knife, followed by the application of a silver nitrate stick for the purpose of producing a flattened scar after the ulcer was healed. Meyer[10] in 1887 also advocated von Graefe's operation, slightly modified. Bow-

1. Cited by Oliver, in Wood, C. A.: A System of Ophthalmic Operations, Chicago, Cleveland Press, 1911, vol. 2, p. 962.

2. Cited by Nance, in Wood, C. A.: A System of Ophthalmic Operations, Chicago, Cleveland Press, 1911, vol. 2, p. 1009.

3. Desmarres d'Evreaux, L. A., cited by Appelbaum,[35] p. 919.

4. Bell, B.: A System of Surgery, ed. 2, Edinburgh, Elliot, 1785, vol. 3, p. 325.

5. Middlemore: A Treatise on the Diseases of the Eye and Its Appendages, 1835, vol. 1, p. 538.

6. Tyrell: A Practical Work on the Diseases of the Eye, London, J. & A. Churchill, Ltd., 1840.

7. Cited by Oliver, in Wood, C. A.: A System of Ophthalmic Operations, Chicago, Cleveland Press, 1911, vol. 2, p. 963.

8. Bowman, W.: Roy. London Ophth. Hosp. Rep. **2**:154, 1859-1860.

9. von Graefe, A.: Arch. f. Ophth. **4**:271, 1858.

10. Meyer, E.: Diseases of the Eye, Philadelphia, P. Blakiston & Sons Company, 1887, p. 149.

man [11] in 1869 and in 1873 resorted to the trephining in removing the superficial layers of the corneal cone. The center of the bulged area thus dissected was punctured and kept open with repeated paracenteses until the cone had flattened. In 1872 Bader [7] claimed to have obtained favorable results by excision of an elliptic piece of full corneal thickness at the apex of the cone. To reduce the danger of prolapse of the iris in Bader's operation and to assist in early closure of the wound, Badal [12] in 1901 inserted three horsehair sutures vertically through the cornea prior to the removal of the apex. The sutures were quickly tied after excision of the elliptic piece of cornea. Critchett [13] in 1895 also advocated the removal of a small elliptic piece of the cone at the apex. The incision was begun with a knife and completed with scissors. Wolfe [14] in 1882 first produced an opacity of the apex of the cone and then made a small artificial pupil behind a transparent cornea. Grandclement [15] in 1891 advocated tattooing of the cone and optical iridectomy. In 1905 Stoewer [15] used a conjunctival flap to cover the cornea after the excision of the cone.

The cautery was used in the treatment of keratoconus as early as 1879 by Gayet [16] and by Andrew [17] in 1884 and by Critchett [18] in 1895. Since then, the number of contributions endorsing the use of the cautery has been immense. Among the many authors recommending cauterization of the apex of the cone are Tweedy [19] and Sattler [20] in 1900; Swanzy,[21] in 1903; Siegrist,[22] in 1916, and Knapp, [23] in 1929. Siegrist recommended cauterization combined with repeated paracente-

11. Bowman, W.: Observations on Various Practical Points of Ophthalmology, Report of Fourth International Ophthalmological Congress, Savill Edwards & Company, 1873, pp. 177-183; footnote 10.

12. Badal: Arch. d'opht. **21**:433, 1901.

13. Cited by Oliver, in Wood, C. A.: A System of Ophthalmic Operations, Chicago, Cleveland Press, 1911, vol. 2, p. 969.

14. Wolfe, J. R.: On Diseases and Injuries of the Eye, Philadelphia, P. Blakiston & Sons Company, 1882, p. 85.

15. Stoewer, W.: Klin. Monatsbl. f. Augenh. **43**:474, 1905.

16. Gayet, cited by Oliver, in Wood, C. A.: A System of Ophthalmic Operations, Chicago, Cleveland Press, 1911, vol. 2, p. 968.

17. Andrew: Brit. M. J. **2**:903, 1884.

18. Critchett, cited by Nance, in Wood, C. A.: A System of Ophthalmic Operations, Chicago, Cleveland Press, 1911, vol. 2, p. 1010.

19. Tweedy, cited by Nuel, Norris and Oliver, System of Diseases of the Eye, Philadelphia, J. B. Lippincott & Company, 1900, vol. 4, p. 252.

20. Cited by Oliver, in Wood, C. A.: A System of Ophthalmic Operations, Chicago, Cleveland Press, 1911, vol. 2, p. 971.

21. Swanzy, H. R.: A Handbook of Diseases of the Eye and Their Treatment, Philadelphia, P. Blakiston & Sons Company, 1903.

22. Siegrist, A.: Klin. Monatsbl. f. Augenh. **56**:400, 1916.

23. Knapp, A.: Keratoconus: Etiology and Treatment, Arch. Ophth. **2**:658 (Dec.) 1929.

ses. Swanzy stated that cauterization should not produce perforation of the cornea, whereas Tweedy and Knapp were supporters of perforation. Elschnig [20] in 1904 superficially cauterized the apex of the cone, as well as an area of the same width connecting the apex with the nearest point of the conjunctiva at the limbus, the object being to produce vascularization with subsequent proliferation of the connective tissue and flattening of the cone. Keratoconus was cured by Carpenter [24] in 1915 with the use of the high frequency spark. Iridectomy was used by von Graefe [25] in 1858 and was advocated by Wells [26] in 1869. Corneoscleral fistulization was recommended by Adams [27] and Tiffany [28] in 1914, by Green [29] in 1920 and by Wibo [30] and Rasquin [31] in 1934. Fox [32] reported in 1925 that flattening of the cone may follow excision of a corneal segment adjacent to the ectatic portion.

Extraction of the lens, which was advocated by Adams [1] in 1817, was employed by Nicolato,[33] in 1930; the latter recommended extraction of the lens in adults and repeated discissions in younger patients.

Sato [34] in 1941 advocated the splitting of Descemet's membrane in an effort to flatten the cornea.

The technics just enumerated are of three types: (1) intraocular operations, (2) excision of a portion of the cornea and (3) flattening of the cornea by cauterization or other means.

The advocates of the first type, intraocular operations, such as paracentesis, extractions of the lens, deviation of the pupil and fistulization, aim to neutralize the corneal deformity with intraocular alterations; but they leave the corneal deformity, with the real cause of poor vision, unchanged.

Advocates of the second type, recommending corneal excision, approach the problem more sensibly because they try to cure or improve the condition by the removal of the deformity in order to obtain a more normal corneal curvature. This type of surgical treatment, however, is too often disastrous to the eye. The operation frequently results in complications, such as high astigmatism, adherent leukoma, often

24. Carpenter, E. R.: Ophth. Rec. **24**:18, 1915.
25. von Graefe, A.: Arch. f. Ophth. **12**:215, 1866.
26. Wells, J. S.: A Treatise on the Diseases of the Eye, Philadelphia, Henry C. Lea, 1869, p. 142.
27. Adams, P. H.: Ophthalmoscope **12**:132, 1914.
28. Tiffany, F. B.: Ophth. Rec. **23**:379, 1914.
29. Green: Am. J. Ophth. **3**:459, 1920.
30. Wibo, M.: Bull. Soc. belge d'opht. **68**:90, 1934.
31. Rasquin, M.: Bull. Soc. belge d'opht. **69**:11, 1934; abstracted, Am. J. Ophth. **18**:789, 1935.
32. Fox, L. W.: Tr. Ophth. Soc. United Kingdom **45**:92, 1925.
33. Nicolato, A.: Arch. di ottal. **37**:74, 1930.
34. Sato, T.: Klin. Monatsbl. f. Augenh. **107**:234, 1941.

extending to the pupillary area, and secondary glaucoma. Therefore these technics have been considered unsatisfactory, and hence have never become popular.

By far the most successful, and the least likely to cause serious intraocular complications, have been the procedures of the third type, for the purpose of flattening the conus by scar tissue formation—whether the scar is brought about by cauterization of the conus with chemicals, electrocautery, high frequency current or the splitting of Descemet's membrane. These surgical procedures result in temporary or permanent improvement of vision, although this improvement seldom approaches vision within normal limits. Furthermore, the scarring designed to flatten the cornea not infrequently defeats the purpose of the operation by leaving the eye with no improvement in vision or with worse vision than before, in addition to corneal opacities which are undesirable from the cosmetic standpoint.

Appelbaum [35] in 1936 published an excellent paper discussing in detail the etiology, pathologic characteristics, symptomatology, objective signs and medical, optical and surgical treatment of keratoconus. Concerning the surgical treatment of this disease, Appelbaum stated:

> Surgical intervention aims to produce flattening of the cornea in order to improve eyesight. When any degree of useful vision is no longer obtainable with the use of contact glasses, operative intervention may be considered—but not sooner. Only in cases of advanced, or nearly hopeless conditions should the patient undergo operation. Most ophthalmologists agree with this. Too much cannot be expected of surgical treatment; at best, it gives a result far from ideal and none too lasting. The unsightliness which inevitably follows must be anticipated, and the appearance of the eye is always marred to some extent.

Afterward, summarizing his discussion on the surgical treatment of keratoconus, Appelbaum stated:

> Finally, in stating an opinion concerning the merits of the operations proposed by an equal number of competent surgeons, one could not improve, even today, on the statement of Wells, in 1873: "All these methods of treatment of conical cornea are still upon their trial and nothing decisive can as yet be said as to their relative advantages and disadvantages."

Entirely agreeing with the statements of Appelbaum and Wells,[36] I was convinced that the choice of a surgical method for the treatment of advanced keratoconus could not be made from the methods previously described. An impartial evaluation of their efficacy proved that more often than not they brought about a deterioration of the eye instead of the improvement they were supposed to accomplish. I also felt that

35. Appelbaum, A.: Keratoconus, Arch. Ophth. **15**:900 (May) 1936.

36. Wells, J. S.: A Treatise on the Diseases of the Eye, ed. 2, London, J. & A. Churchill, Ltd., 1873, p. 145.

only patients whose condition is considered hopeless—whose vision cannot be improved by the use of ordinary lenses or contact lenses, or who cannot tolerate contact lenses—should be subjected to operation.

The advent of contact lenses enabled many sufferers from keratoconus whose vision could not be improved with ordinary glasses to obtain useful vision; but there are still many whose vision, on account of dense scarring at the apex, cannot be improved with the use of contact lenses. There are others who with the aid of contact lenses have restoration of fairly good vision, but, who, owing to ever increasing irritation, do not tolerate the contact lenses well. In still another group of patients, contact lenses are not satisfactory because of their tendency to cause cloudiness of the cornea or because the buffer solution becomes turbid too rapidly. For all these patients with advanced keratoconus, with very precarious vision—less than 20/200 (industrial blindness)—whose vision does not improve with ordinary or with contact lenses or who do not tolerate the contact lenses well surgical intervention is justified.

REQUIREMENTS IN SURGICAL TREATMENT OF KERATOCONUS

In the successful treatment of keratoconus two requirements must be observed: 1. Since poor vision seems to be caused by the corneal deformity alone, and not by other intraocular pathologic conditions, surgical procedures must be limited to the cornea.

In order to obtain the best possible vision, the whole corneal protrusion must be removed and replaced with corneal tissue of normal curvature and thickness. The pupillary area must be free of scarring.

The only surgical procedure which fulfils these two requirements is keratoplasty of the partial penetrating type. Therefore, keratoplasty seems to me the logical procedure in advanced cases of keratoconus when useful vision can no longer be obtained with the use of ordinary or contact lenses or when contact lenses are not well tolerated.

In 1936 I [37] performed the first keratoplasty in a case of advanced keratoconus, with resulting pronounced improvement of vision and seemingly lasting cure. Encouraged by the first trials, I proceeded to treat other patients with advanced keratoconus with corneal transplantation. The results have been most encouraging. A high percentage of patients remain with clear grafts, marked improvement of vision and, so far as my twelve years' experience indicates, permanent cure. I have already operated on more than 200 persons with advanced keratoconus, and in more than 80 per cent the results can be considered most successful. The average improvement of vision that can be expected is from 20/200 or less to 20/50 or better (figs. 1 and 2).

37. Castroviejo, R.: Internat. Abstr. Surg. **65**:5, 1937.

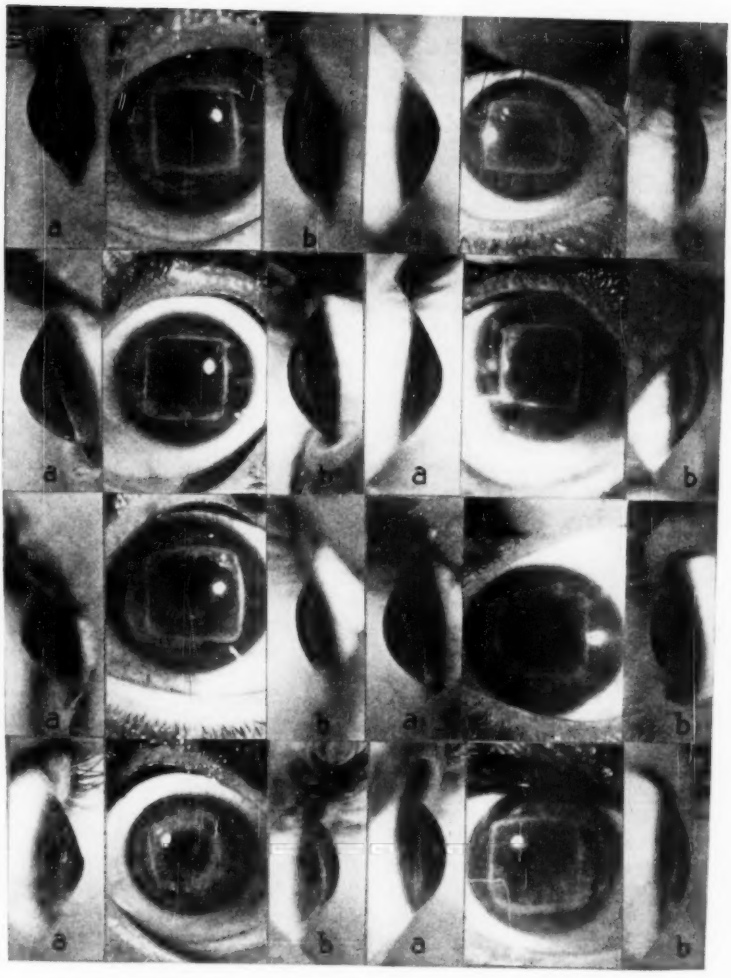

Fig. 1.—Clear square corneal transplants in eyes with advanced keratoconus. Profiles show the cornea (*a*) before operation and (*b*) after operation.

I have singled out keratoconus for this discussion on keratoplasty because keratoconus has special features which distinguish it from other corneal opacities or deformities. Failure to observe certain rules in the treatment of keratoconus by keratoplasty may defeat the success of the operation. The rules concerning these special features must be taken into consideration during the preoperative study, at the time of the operation and during postoperative recovery.

PREOPERATIVE STUDY

During the preoperative study, the thickness of the cornea and the extent of the keratoconus must be carefully studied with the slit lamp and the corneal microscope. It is important to know how extensive the keratoconus is, because the size of the graft and its location depend on the extent and location of the conus. The graft must be large enough to substitute for all, or as much as possible, of the conus. If the transplant is smaller than the conus, the deformity is likely to progress. The graft will not form a keratoconus, but the remaining thin cornea will

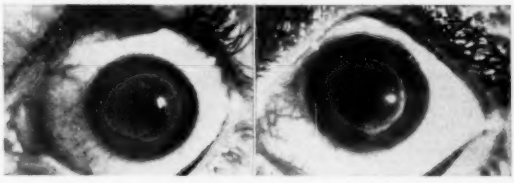

Fig. 2.—Clear circular transplants in eyes, with advanced keratoconus.

continue to protrude; or, if it does not advance after the operation, the graft, although clear, remains set in a protruding area of cornea, which results in very high myopia or astigmatism or both, thus defeating the visual purpose of the operation.

The patient shown in figure 3 serves to illustrate this point. He had advanced keratoconus in both eyes; vision in each eye was equal to counting fingers at 1 foot (30 cm.), and, on account of the pronounced conus, he could not be fitted with comfortable contact lenses. A corneal transplantation was performed on the right eye, using a 4.5 mm. graft (fig. 3 *a*). The transplant remained clear but was set in a protruding area, which resulted in very high myopia and astigmatism. Vision improved only slightly after the operation because of the remaining protrusion. In the fellow eye, a keratoplasty was performed afterward, using a transplant of 5.5 mm. (fig. 3 *b*). Again, this transplant was found to be too small; thin cornea remained, with subsequent protrusion of the graft and only slight improvement in vision. A third transplant, of 6 mm., was then used (fig. 3 *d*), the second on the left eye, but

still it was not large enough to permit excision of the whole conus. The result was moderate protrusion and high myopia of —20 D. Corrected vision was 20/50. Finally, the right eye was again operated on, and, with the experience of three previous operations, a larger transplant of 7 mm. (fig. 3*c*) was used, by means of which the whole conus was excised. Fairly good corneal curvature was obtained, and with a correction of —4.00 sph. ⊃ —1.75 cyl., axis 120 vision was 20/25—3.

The smallest graft to be used in correction of keratoconus should be 6 mm., except in some cases of an extremely small conus. In such instances grafts of 5.5 mm., or even less, can be used. In cases of more pronounced keratoconus, grafts of 6.5 mm., or as large as 7 mm., are necessary.

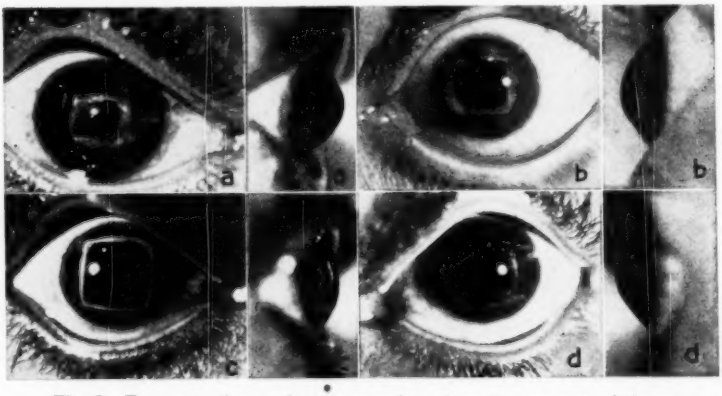

Fig. 3.—Four corneal transplantations performed on the two eyes of the same patient: (*a*) 4.5 mm. graft; (*b*) 5.5 mm. graft; (*c*) 7 mm. graft; (*d*) 6 mm. graft.

It is always desirable to place the graft in the center of the cornea in order that the center of the graft will coincide with the center of the pupil. In cases of keratoconus, however, the location of the graft must be controlled to a certain extent by the location of the conus. When the conus is off center, the graft should be displaced accordingly, in order to remove as much as possible of the protruding area. In this case, if the graft is small (less than 6 mm.), its edge may fall in or near the pupillary area, interfering with vision. This interference is, of course, greater if the cicatrix is made more pronounced during the healing process, thus reducing the useful area of the graft falling within the pupillary area (fig. 4*B*). If the graft is large (6 mm. or more), even in case of abundant scarring at the edges there is always enough useful area of the graft in the pupillary area.

This useful area for the same size of graft is larger in the square graft than in the circular one if the corners are placed as illustrated in figure 4 *A*. This fact should make the square graft more desirable than the circular one in a case of large keratoconus. In addition, the corners in the square graft extend farther toward the limbus, and

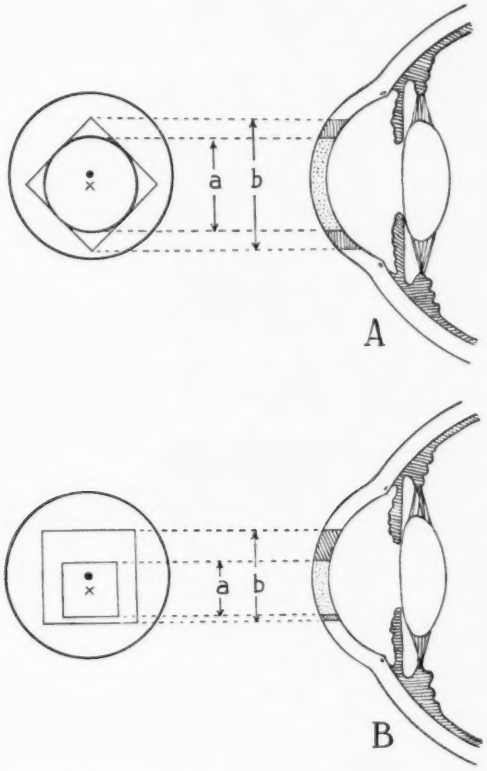

Fig. 4.—Diagrams showing (*A*) the position of the edges of eccentrically placed round (*a*) and square (*b*) grafts in relation to the pupillary area (the dot shows the center of the cornea, while the cross shows the center of the graft); (*B*) the position of the edges of the eccentrically placed small graft (*a*) and larger graft (*b*).

the scarring which takes place at the incision has a tendency to greater flattening of the graft and the cornea of the host, resulting in better curvature, than when a round graft is used. In order to accomplish the

same effect, a round graft would have to be much larger, corresponding to the distance, not from opposite sides of the square graft, but from corner to corner (fig. 5).

Another factor which must be considered before operation is the dilation of the pupil. When large grafts are used, the pupil should be widely dilated to prevent the formation of anterior synechia, one of the most frequent complications in keratoconus. The pupil generally dilates widely with repeated instillations of 3 per cent solution of atropine sulfate and 10 per cent emulsion of phenylephrine (neo-synephrine®) hydrochloride. If the pupil should fail to dilate beyond the limits of the area where the graft will be located in the cornea, it is preferable to use a smaller graft or to prepare the eye with a large iridectomy rather than

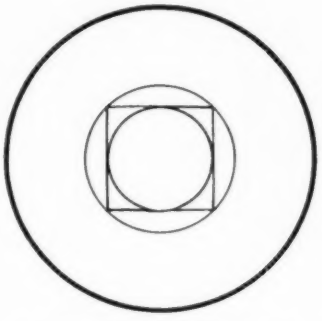

Fig. 5.—Diagram showing the relation of useful vision for grafts of the same size in the square and in the round transplant.

risk the development of anterior synechia, with subsequent danger of opacification of the graft or secondary glaucoma or both.

In addition to these local factors in the eye, the general condition of the patient should be carefully studied, eliminating all pathologic conditions which are likely to influence the normal postoperative course of the transplant, such as foci of infection, malnutrition and other systemic conditions. Infections in the nose and throat are particularly likely to cause postoperative uveitis, and it would be advisable not to perform a corneal transplantation in the presence of infected tonsils or pathologic conditions of the nose, including involvement of the sinuses, but to delay the operation until these conditions have been cleared up by medical or surgical treatment.

The two types of operation performed in this series have been the square and circular partial penetrating keratoplasties, illustrated in

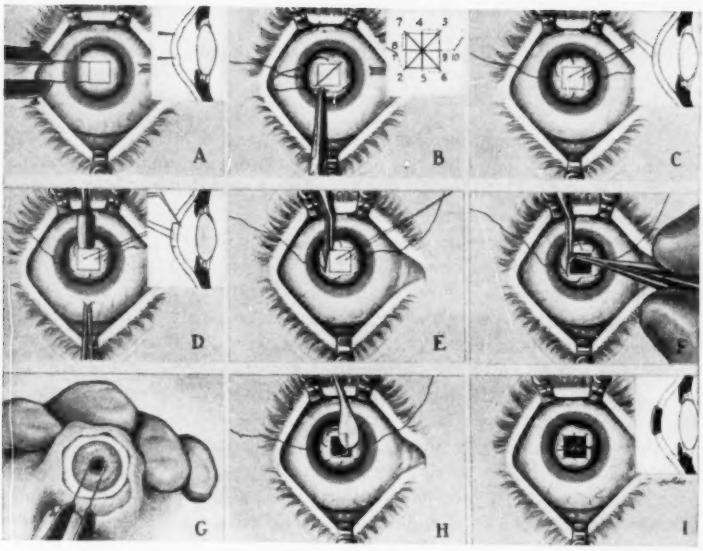

Fig. 6.—Successive steps in the Castroviejo square partial penetrating keratoplasty.

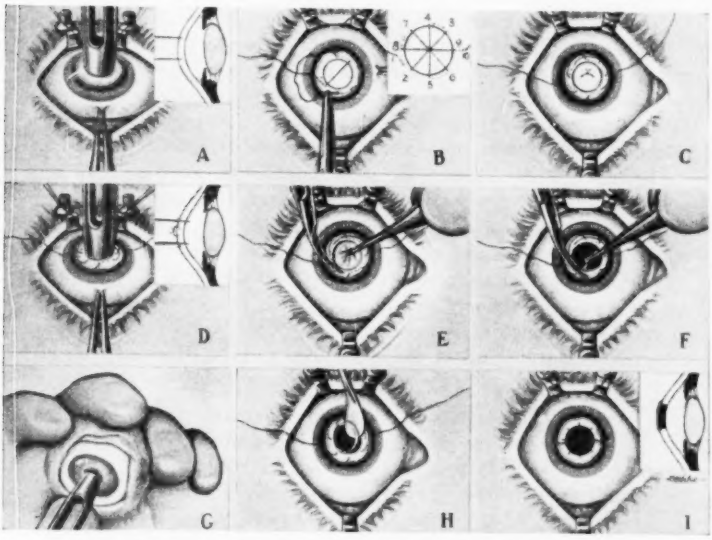

Fig. 7.—Successive steps in the Castroviejo circular partial penetrating keratoplasty.

figures 6 and 7. A detailed description of the operation has been given in another article.[38]

THE OPERATION

It has already been mentioned that the cornea of the conus is sometimes reduced to one-fifth the normal thickness and that in extreme cases it may be still thinner. On account of this thinness, the cornea may be perforated while the incisions are being outlined or the sutures are inserted. If the perforation occurs while the incisions are being outlined, whether with the double-bladed knife or with the trephine, before the sutures have been inserted, it may be difficult to continue the operation. However, the surgeon well trained in keratoplasty will be able, although with more difficulty, to continue with the operation and to place the sutures after the cornea has been perforated, particularly if the suture material is good. In this event, the remaining (uncut) portion of the incision must be completed with the aid of scissors, both in the square and in the circular graft. For the surgeon less skilled in this type of operation, it would be preferable to postpone the operation for about a week, to provide time for the cornea to close the opening firmly and the anterior chamber to reform, before proceeding with the operation.

If the perforation of the cornea takes place while the sutures are being inserted, because the anterior chamber has been entered with the needle, the aqueous humor will drain slowly, rendering the eye hypotonic. If this complication takes place in eyes with normal corneal thickness, it is feasible—and not difficult—to withdraw the needle and pass it through more superficial layers of the cornea; otherwise, a fistula may form during postoperative recovery, with drainage of aqueous humor, flattening of the anterior chamber and likelihood of intraocular infection, development of anterior synechia and secondary glaucoma.

In the area of keratoconus, it is possible to carry out the same maneuver of withdrawing the needle and passing it through more superficial layers of the cornea; but, because of the extreme thinness of the cornea in some cases and its lack of rigidity and resiliency, the cornea collapses and wrinkles (fig. 8*A* and 8*B*), so that the reinsertion of the needle may be extremely difficult. In these circumstances, also, the surgeon well trained in keratoplasty may proceed with the operation to a successful conclusion; for the less skilled surgeon, however, it would be preferable to postpone the surgical procedure rather than risk failure in the operation.

After the removal of the conus, particularly in eyes in which a large transplant of 6.5 mm. or more is used, the pupil may be found to be without sufficient dilatation and the size of the pupil to be smaller than

38. Castroviejo, R.: Am. J. Ophth. **24**:1 (Jan.); 139 (Feb.) 1941.

the opening in the cornea. This situation can be prevented before the operation, as has already been noted, by repeated instillations of 3 per cent atropine sulfate and 10 per cent emulsion of phenylephrine hydrochloride and, at the time of the operation, by injection under the conjunctiva of 2 per cent cocaine and a solution of epinephrine hydrochloride (1:1,000). If, in spite of this preparation before the graft is placed in position, the pupil is smaller than the opening in the cornea, direct instillation of 4 per cent cocaine and solution of epinephrine hydrochloride (1:1,000 or even 1:100) into the corneal opening may dilate the pupil wider than the corneal window. If, in spite of the instillations,

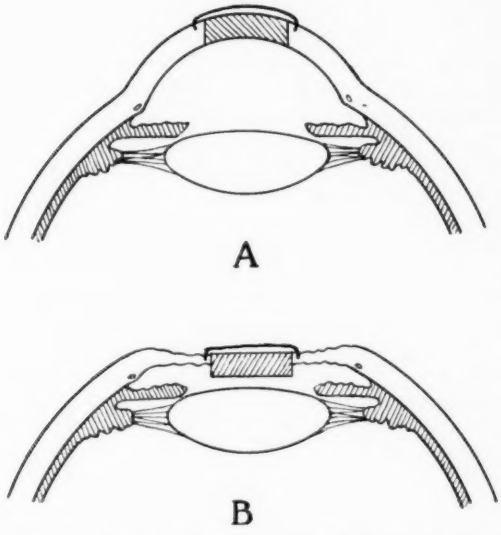

Fig. 8.—Diagrams showing (*A*) resilient cornea holding the graft in position and (*B*) collapsed and wrinkled thin cornea held in position around the graft by sutures placed close to the borders.

the iris shows within the opening, it is advisable to excise the involved portion of iris and place sutures from border to border, as illustrated in figure 9, a procedure which, although injuring the graft somewhat, gives a better coaptation of the borders, promoting early restoration of the anterior chamber and tending to avoid the development of anterior synechia. The performance of an iridectomy in these cases will, of course, be contested by those who perform keratoplasty with contracted pupil. Statistics will show in the future which method gives the greater number of anterior synechias—the one using the contracted pupil or

the one using the dilated pupil. Both my experimental work on animals and my clinical experience have proved to me that when the pupil is left contracted at the time of placing of the graft, anterior synechia is more likely to develop.

Because of the lack of resiliency of the cornea and the large grafts generally used in cases of advanced keratoconus, it is easier to injure the lens while perforating the cornea than while operating on eyes with normal corneal thickness and resiliency, in which smaller grafts are usually used. Therefore, in making the corneal perforation, particularly with the trephine, great care must be exercised to withdraw the trephine quickly, immediately after penetration into the anterior chamber has taken place, because the cornea collapses and the lens capsule comes into contact with the edge of the trephine almost instantly. Because of the large area of lens exposed when the graft is large, the lens is more easily injured while the border of the incision is being trimmed, if that should be necessary. Therefore, the extreme care that must be exercised during these manipulations to avoid injury to the lens cannot be emphasized too strongly.

I wish to mention another complication that may occur in cases of advanced keratoconus. In 1 instance I used a square transplant of 7 mm. to replace completely the extensive area of extremely thin cornea of the keratoconus. After the conus was excised, without injury to the lens, the lens mushroomed through the corneal opening and spontaneously extruded itself intact in its capsule. In this case, in order to maintain the graft firmly in position, it was necessary to suture the border of the graft to the border of the cornea of the host, using eight sutures, in the manner illustrated in figure 9.

If the lens is injured by the keratome or trephine or scissors while one is completing the incision, it is advisable to remove as much as possible of the injured lens, including the capsule. In this complication, the vitreous has a tendency to prolapse during the operation or the postoperative recovery, and thus to dislocate the graft. Therefore, it is advisable in these cases, in order to maintain the graft firmly in position, to suture the graft to the cornea of the host, border to border, as illustrated in figure 9.

In the case of large grafts, it is advisable to have the graft ready before the excision of the cornea of the host, in order not to delay the closing of the corneal opening as soon as the dissection of the conus has been concluded.

In corneas with keratoconus, contrary to what occurs in corneas with normal thickness and resiliency, there is a tendency for the cornea to collapse. This often results in an opening of the host cornea smaller than the graft, although the graft had been made the same size as the corneal opening. In this case, contrary to what happens with corneas

of normal thickness and normal resiliency, in which the cornea of the host holds the graft, it is the graft that holds the thin cornea of the host around it. In these circumstances, the displacement of the whole graft, or part of the edge of the graft, is not infrequent. In order to prevent this displacement of the graft, two essential points must be observed in placing the sutures: 1. The sutures must be placed near the edge of the incision. 2. The distance between the sutures must be shorter than the diameter of the graft.

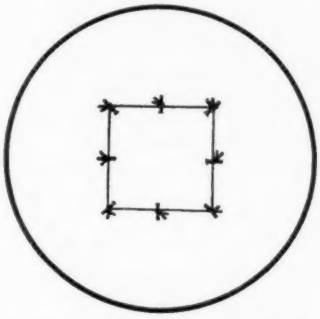

Fig. 9.—Diagram showing border to border suturing in a square transplant.

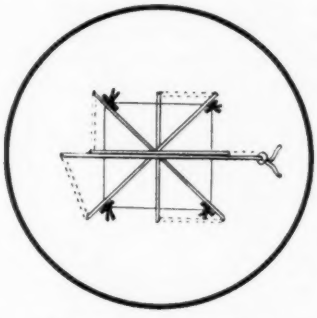

Fig. 10.—Diagram showing Castroviejo's continuous suture to hold the graft in position, reenforced by four border to border sutures placed in the corners of the graft to prevent its displacement.

In spite of these precautions to prevent displacement of the graft, it is sometimes difficult to hold the graft in position in cases of large grafts. In such cases direct suturing of the border of the cornea of the host to that of the donor is recommended. At least four sutures placed in the corners of the square graft, or at the ends of two perpendicular diameters in the circular grafts, are advisable (fig. 10).

Another essential point which must be observed in operation for keratoconus concerns the type of donor material to be used. Since in case of keratoconus with thin cornea it is not the cornea of the host which holds the graft in place, but the graft that holds the cornea of the host around it, it is preferable that the graft be obtained from adult eyes. Younger material from fetuses, stillborn infants or infants does not have enough resiliency to hold the cornea of the host around the borders of the graft.

In cases of eccentric keratoconus extending toward the limbus, the graft must be displaced off center to coincide with the position of the deformity. In these cases the graft must be large enough to permit enclosing the pupillary area within the graft; otherwise, the scarring at the edges of the graft will interfere with vision. Of the circular and square grafts, the square graft placed with the corners as illustrated in figure 4 *A* is preferable, because it includes not only the displaced conus, but also the central area of cornea, most desirable for useful vision.

POSTOPERATIVE RECOVERY

During the postoperative recovery, there is more danger of displacement of the graft in eyes operated on for keratoconus than in eyes operated on for other corneal conditions with normal corneal thickness, in which smaller grafts are used. For this reason, the patient should have both eyes bandaged and remain quiet in bed, with fluid and semifluid diet, for about seven days. During this period the eye should not be examined. Examination of the eye prior to the seventh postoperative day increases the danger of complications, particularly displacement of the graft, with development of anterior synechias. On the seventh postoperative day, the eye is examined for the first time and penicillin ointment and ointment containing 1 per cent atropine sulfate are applied to dilate the pupil. The reactions of the patient are tested at this time. If the patient is quiet, and not tense, and gives good cooperation, permitting examination of the eye without blepharospasm, the sutures can be removed the following day, with use of local anesthesia. But if the patient is tense, of the high-strung type, with pronounced blepharospasm—a "squeezer"—the sutures should be removed the following day with the use of general anesthesia, preferably that produced by thiopental sodium. The purpose of applying atropine is to obtain dilation of the pupil, for, in the case of keratoconus with thin cornea, at the time the corneal sutures are removed there may be a collapse of the anterior chamber with loss of aqueous humor, due to slight dehiscence of the incision. Seldom, however, is this opening extensive, and the transplant almost always cicatrizes well in spite of the collapse of the anterior chamber and without complications such as development of

anterior synechia. An anterior synechia is less likely to occur if the pupil has been widely dilated prior to the removal of sutures with the use of atropine sulfate.

The development of an anterior synechia is one of the most frequent complications in keratoplasty for the treatment of keratoconus. If the synechia is smaller than 2 mm., occasionally the use of atropine or physostigmine loosens it. If the synechia is more extensive, surgical intervention will be necessitated in order to prevent opacification, vascularization of the graft and, often, secondary glaucoma. The surgical treatment of the synechia must not be carried out before the fourteenth postoperative day because until then the union of the graft with the cornea of the host is not firm and premature surgical procedures might lead to dislocation of the graft. The operation, however, should not be delayed beyond three weeks, otherwise the graft may already have become opaque on account of the synechia. Therefore, the best time to carry out this procedure is in the third postoperative week, preferably with the patient under general anesthesia.

SURGICAL TECHNICS FOR TREATMENT OF ANTERIOR SYNECHIAS

If the synechia extends from one fifth to one half of the circumference of the graft, the operation of choice is as follows:

Depending on the location of the synechia, the incision in the sclera is made in the quadrant nearest the synechia: in the lower temporal for synechia in the lower half of the transplant; in the upper temporal for synechia in the upper half. A routine preparation of the eye, about one hour before the operation, is made with instillation of 3 per cent atropine sulfate and 10 per cent phenylephrine hydrochloride, in order to obtain as wide a dilation of the pupil as possible. At the time of the operation, after routine preparation of the eye, 25 per cent mild silver protein U. S. P., a 4 per cent solution of cocaine and a solution of epinephrine hydrochloride (1:1,000) are instilled into the eye. A few drops of the cocaine solution and the epinephrine hydrochloride are injected under the bulbar conjunctiva (fig. 11 *A*) for the purpose of obtaining ischemia and wider dilation of the pupil and of counteracting a tendency to contraction after the anterior chamber has been opened.

An incision is made through the conjunctiva and Tenon's capsule, about 7 mm. from the limbus and parallel to it (fig. 11 *B*). Two 00 silk sutures are inserted in the sclera 4 and 6 mm., respectively, from the limbus and parallel to it. These sutures are used for fixation; one of them is held by the assistant and the other by the surgeon. The area of the sclera between the two sutures is treated by superficial electrocoagulation or by a hot probe to obtain a bloodless operative field (fig. 11 *B*). With the knife, an incision is made in the sclera similar to that performed for cyclodialysis (fig. 11 *C*). When the

sclera has been perforated and the choroid is reached, a long spatula similar to that used for cyclodialysis, but 15 mm. in length, is introduced through the scleral opening and then between the sclera and the choroid into the anterior chamber. The adherent iris is separated from the cornea with the aid of the spatula (fig. 11 *D*). The spatula is then withdrawn and the tip of a Randolph perforated cannula, with the shape of a cyclodialysis spatula attached to a syringe (fig. 11 *E*), is introduced in the same manner as the spatula into the anterior chamber and air is injected to push the iris away from the cornea. The cannula is then withdrawn and the conjunctival incision closed with a

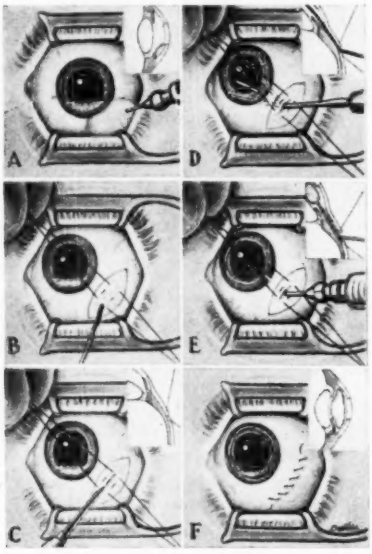

Fig. 11.—Successive steps in the Castroviejo technic for the treatment of moderate anterior synechias.

continuous 000000 silk suture. This cyclodialysis incision placed several millimeters from the limbus is preferable to incisions in the limbus because with the latter it is not always possible to keep the air within the anterior chamber long enough to prevent the recurrence of the synechia.

When the synechia is extensive, the operation which I have found satisfactory is as follows:

The operation should be carried out, preferably, with the patient under general anesthesia. With the aid of scissors and conjunctival forceps, a conjunctival and episcleral flap of 2 to 3 mm. between 10

and 2 o'clock is made around the limbus (fig. 12 *A*). The conjunctival flap is reflected down over the cornea and three 000000 silk sutures mounted in atraumatic needles are inserted, one at 12 o'clock and the other two equidistant from the central one and the ends of the conjunctival incision. The sutures are passed first through the conjunctiva and then through the sclera, entering the sclera about 2 mm. from the limbus and taking a bite of about 1 mm. (fig. 12 *A*). The sutures are now drawn out of the way in order to make the incision with a minimum of interference. With the knife, an ab externo incision is made at the limbus around 12 o'clock (fig. 12 *A*). When the anterior cham-

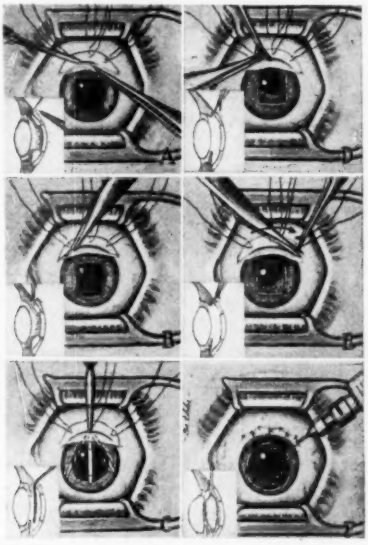

Fig. 12.—Successive steps in the Castroviejo technic for the treatment of extensive anterior synechias.

ber is entered, the incision is enlarged temporally and nasally with the aid of scissors (fig. 12 *B*). With the cyclodialysis spatula, the iris is then separated from the cornea (fig. 12 *C*).

A large iridectomy from 10 to 2 o'clock is then performed (fig. 12 *D* and *E*). The sutures are passed through the corneoconjunctival junction, including a small bite of corneal tissue, and tied. Additional conjunctival sutures are inserted, and air is injected into the anterior chamber (fig. 12 *F*) in an effort to push the iris away from the cornea, thus preventing the recurrence of the synechia.

After this procedure, if an anterior synechia develops in the lower half of the graft, the first operation described can be carried out. In several cases in which the two operations were carried out successively, the eye remained without synechias, with a clear transplant and good vision (fig. 13).

In these two operations, bacteria leading to endophthalmitis or panophthalmitis are often introduced into the eye. I have had several such instances; therefore the need of a meticulously aseptic technic and great care in performing these operations should be stressed. Prophylactic treatment with systemic application of penicillin should be carried out, beginning the day prior to the operation and continuing until all the signs of inflammation in the eye have disappeared. In addition, intravenous injections of typhoid vaccine should be instituted.

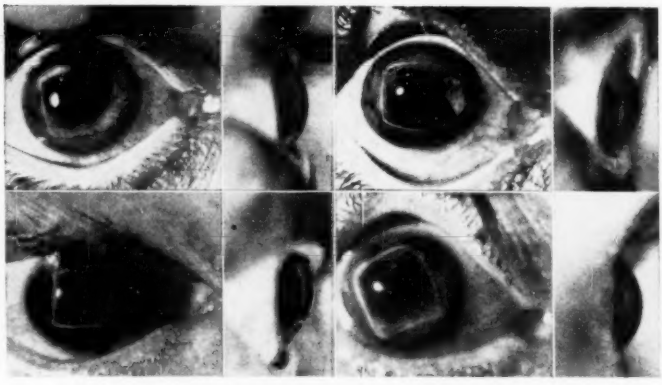

Fig. 13.—Clear transplants after operations for extensive synechia.

In keratoconus, the transplant often has a tendency to protrude during the postoperative course. This must be considered not as a complication, but almost as the normal cicatrization of the grafts in repair of keratoconus.

In order to obtain a more normal curvature, it is necessary to maintain a pressure dressing, which is started on the fifteenth postoperative day and is continued until the fifth or sixth postoperative week. During the first week of the pressure dressing the pressure must not be too strong; otherwise the incision may reopen, leading to development of anterior synechias. However, in the following weeks the pressure can be substantially increased, until as much pressure as possible is applied by the fourth week. It is not necessary, in order to insure adequate pressure, to use bandages of the roll type around the head, which some-

times make the patient very uncomfortable. I have found that the dressing illustrated in figure 14 gives adequate pressure for about two days. For this pressure dressing to be effective, it should be carried out in the following fashion:

The ocular area within the rim of the orbit should be well packed with gauze and two rows of strips of adhesive tape applied, pressure being exerted with the first strip of adhesive tape, with the second row

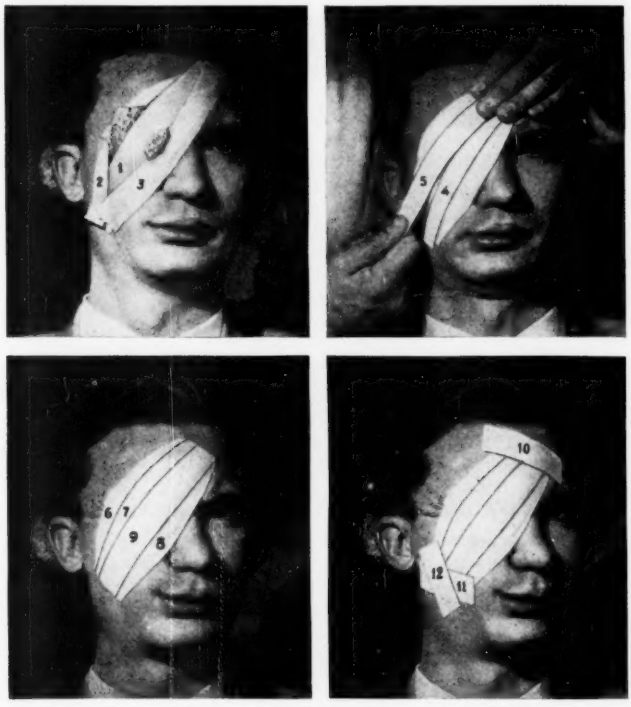

Fig. 14.—Photographs showing successive steps in the application of pressure dressing.

reenforcing the pressure obtained with the first row. The ends of the adhesive tape on the cheek and on the forehead should be held tightly in position by other strips of adhesive tape in order to prevent curling of the edges and loosening of the bandage.

With this pressure dressing, a good curvature of the cornea may already have been obtained by the fourth postoperative week. The

pressure dressing must then be applied with care, so as not to produce too much pressure and to avoid excessive flattening of the cornea, which might result in high hypermetropia, astigmatism or even contact of the cornea with the iris and the development of anterior synechias.

The same type of pressure bandage has been found useful in the treatment of acute ectasia or hydrops, a frequent complication of keratoconus. The bandage is continued until the ectasia has entirely disappeared and the eye has become quiet (fig. 15).

Sometimes in keratoconus, with more frequency than in any other corneal deformity treated by corneal transplantation, the transplant remains protruding for over four weeks in spite of the pressure dressing, apparently owing to the thinness of the edge in the recipient cornea. In these circumstances, the nutrition of the graft is impaired, often

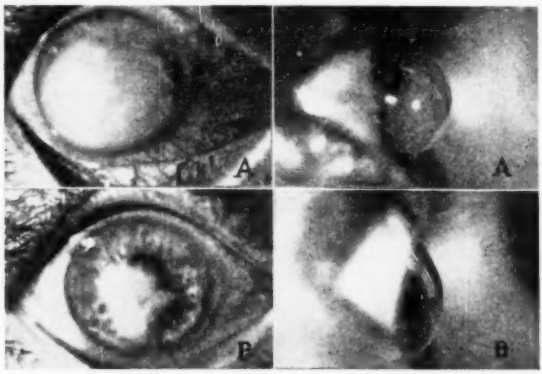

Fig. 15.—Photographs of acute ectasia before (*A*) and after (*B*) application of pressure dressing.

leading to cloudiness of the graft and occasionally to the development of corneal edema with bullous degeneration of the epithelium. This corneal edema is generally improved by applications of hypertonic sodium chloride, as a 15 per cent jelly, from three to six times daily. If the bullous degeneration of the epithelium fails to clear up with this conservative treatment, it is advisable to scrape the epithelium and treat the denuded area and about 1 or 2 mm. of the surrounding cornea with light superficial electrodesiccation. With this treatment, the bullous degeneration of the epithelium will disappear, but at the expense of permanent superficial cloudiness of the graft, which will require further surgical correction if the cloudiness is sufficient to impair vision greatly.

If, in spite of the application of pressure dressing, the transplant should cicatrize with protrusion, or uneven curvature, resulting in pro-

nounced myopia and astigmatism, although preserving permanent transparency, the operation is a failure for visual purposes. Contact lenses may occasionally help this situation; if not, a second transplant, preferably larger than the first, will be necessary.

I have mentioned here only the complications most likely to occur in operations for keratoconus. Other complications observed in corneal transplantation have been discussed in another article.[39]

RETRANSPLANTATION

If the transplant should become cloudy, because of protrusion during postoperative recovery, anterior synechias successfully treated surgically or postoperative uveitis, but no complication, such as opacity or vascularization, has developed in the surrounding cornea, the eye is still

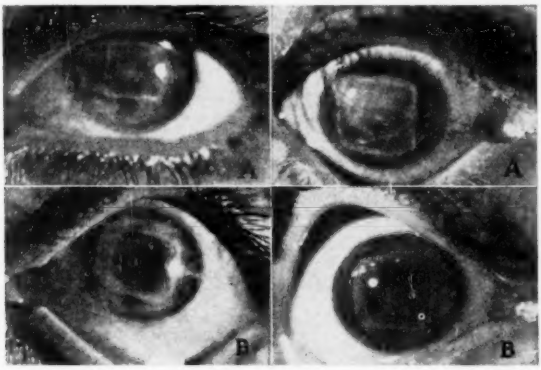

Fig. 16.—*A*, cloudy transplants, and *B*, clear retransplants.

favorable for another corneal transplant. At least six months, but preferably a year, should elapse, however, before the second transplantation, in order to provide time for the eye to become entirely quiet. Figure 16 shows transplants which remained clear after a second operation, when the previous one had resulted in a cloudy graft.

CLOUDINESS OF THE GRAFT

In cases of delayed cicatrization due to protrusion or complicating uveitis, the transplant may become cloudy to the point where the patient can see only to count fingers or distinguish hand movements at 1 foot, but sometimes these transplants clear up in a few months to such an extent that it is no longer possible to detect any cloudiness of the graft,

39. Castroviejo, R.: Tr. Am. Acad. Ophth. & Otol. 1948, pp. 322-330.

with vision improving sometimes to 20/30, and even 20/20 (fig. 17). This clearing-up process can be expected to take place within a year after the operation. Any opacity remaining after the first year may be considered permanent, requiring further surgical treatment if vision remains poor.

In some cases of extremely pronounced keratoconus, approaching keratoglobus in appearance, I have tried to flatten the cornea by superficial electrodesiccation in order to obtain more normal curvature and render the eye more favorable for keratoplasty. So far, however, this procedure has always resulted in failure.

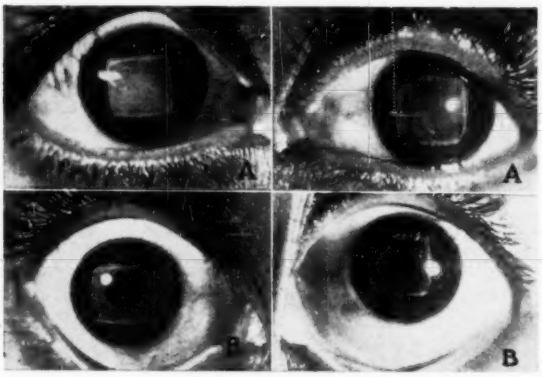

Fig. 17.—Cloudy transplants (*A*), after uveitis, which finally cleared up (*B*).

COMMENT

I am convinced that partial penetrating keratoplasty is the treatment of choice for advanced keratoconus. When a suitable technic is used, the percentage of cases of permanently greatly improved vision should be high, from 75 to 90 per cent. The percentage of successful cases will, of course, be higher the more experienced and skilled the surgeon. The surgeon less experienced in keratoplasty given the proper selection of cases and technic, and taking into consideration the observations here presented, may also expect a high percentage of satisfactory results.

9 East Ninety-First Street.

UNILATERAL THROMBOSIS OF A CAVERNOUS SINUS TREATED WITH PENICILLIN AND SULFADIAZINE

Report of a Case with Follow-Up Study

M. E. GANS, M.D.
AND
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CLEVELAND

IN THE prechemotherapeutic era thrombosis of a cavernous sinus was a condition with an extremely grave prognosis. Whether septic or aseptic, thrombosis of a cavernous sinus carried with it a high mortality. Therapy was mainly expectant and palliative. The clinical course of the disease has been well described by Lyle [1]:

> Early symptoms on the part of the eye are caused by interference with the venous drainage from the eye and orbit. There is discoloration and swelling of the lids with exophthalmos. The conjunctiva is congested. The orbit shows increasing edema with gradual immobilization of the eyes, both from orbital swelling and involvement of the third, fourth and sixth nerves in the sinus. Ophthalmoscopic examination shows an initial edema of the retina with dilated veins. Papilledema is not uncommon. Retinal hemorrhages are occasionally present. As the condition progresses, the media becomes hazy so that the fundus cannot be seen. Pain in the orbit is usually marked. Later, the patient passes into a comatose state with fever and other symptoms of systemic involvement.

Dandy [2] stated that extension to the opposite cavernous sinus through the circular sinus and backward to the lateral sinus occurred in about half the cases. Venous ligation in the neck was frequently necessary to prevent dissemination of metastatic septic emboli. Meningitis and death were so common as to be considered the rule.[3]

Chemotherapy has produced a notable change in this morbid picture. The following case history of unilateral thrombosis of a cavernous sinus following skull fracture is illustrative.

REPORT OF CASE

Mr. J. N., a white man aged 58, presented himself at our offices with a history of left-sided frontal headache radiating to the occiput, which had begun overnight

1. Lyle, D. J.: Neuro-Ophthalmology, Springfield, Ill., Charles C Thomas, Publisher, 1945.
2. Dandy, W. E., in Lewis, D.: Practice of Surgery, Hagerstown, Md., W. F. Prior Company, Inc., vol. 12, chap. 1, p. 425.
3. Eagleton, W. P.: Cavernous Sinus Thrombophlebitis, New York, The Macmillan Company, 1926.

about two weeks previously. The headache was almost constant, was not accompanied with nausea or vomiting and was not relieved by simple home remedies, such as acetylsalicylic acid. After the first week of the headache, tinnitus had appeared in the left ear, and in the two days prior to his first office visit the patient had noted diplopia and some redness of his left eye, which prompted him to seek medical attention. There was no history of infection about the face, and at this time the patient could not recall having received any trauma. The past history was essentially without significance except for asthma five years previously, which was relieved by desensitization therapy.

Ocular examination revealed the following condition: Vision was 20/20 in each eye. There was mild conjunctival injection of the left eye with slight chemosis below. There was no proptosis. There was complete paralysis of abduction of the left eye, but other extraocular movements were entirely normal. Both pupils reacted normally to light and in accommodation. Both fundi were entirely normal in appearance. Visual fields taken with a 3 mm. white target at 330 mm. were normal, and the blindspots were of normal size and configuration. In the few days that followed, the chemosis increased, the retinal veins became

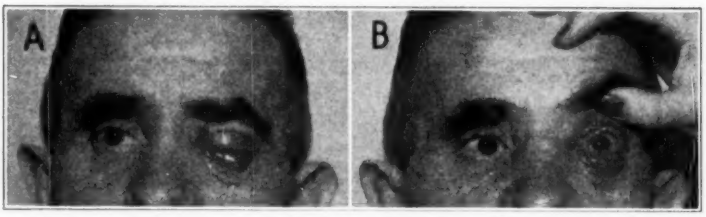

Fig. 1.—Appearance of the patient on admission to the hospital. (*A*) The conjunctival prolapse, edema and ptosis are apparent. (*B*) The patient was instructed to look to the left. The paralysis of the left abducens nerve is apparent.

slightly fuller on the left and ptosis and proptosis began to appear, so that on May 1, 1947 the patient was admitted to Mount Sinai Hospital for study and treatment.

On his admission to the hospital, physical examination revealed a well developed, well nourished white man, whose alertness was somewhat dulled and who complained of headache in the left frontal area but was in no distress. The left orbit was edematous; the lower bulbar conjunctiva was chemotic and prolapsed, and his left eye was proptosed, as shown in figure 1 *A* and *B*. There was no fluctuation in the left orbit and no bruit was audible. The temperature on admission was 99.2 F; the pulse rate was 82 and the respiratory rate 20. His blood pressure was 138 mm. of mercury systolic and 80 mm. of mercury diastolic. Except for the ocular changes, the physical and neurologic condition was entirely normal. Treatment was started with parenteral administration of 320,000 units of penicillin daily in divided doses. On the second hospital day, a roentgenogram of the skull revealed a linear fracture of 7 cm. in the left half of the occipital bone, as seen in figure 2. There was no fragmentation or depression. The orbits were intact, and there was no evidence of fracture of the walls of the maxillary sinuses or zygomas. Confronted with the roentgenographic findings, the patient vaguely recalled that three weeks prior to admission

he had fallen and struck the left side of his forehead on a curb and that his headache seemed to date from the following morning.

On the fourth hospital day, the orbital edema had increased to such an extent that the left eye was completely immobile and the nerve head was very pale, and not elevated. Scattered hemorrhages were seen in the left fundus. Oral administration of sulfadiazine in an initial dose of 2 Gm., followed by 1 Gm. every four hours, was added to penicillin therapy (so long as sulfadiazine was being given, repeated determinations of the blood level showed between 4.1 and 8.4 mg. of sulfadiazine per hundred cubic centimeters). The outer canthus was divided surgically in an effort to reduce pressure of the lids on the globe. On the fifth hospital day a lumbar puncture was made. The spinal fluid was clear; the pressure

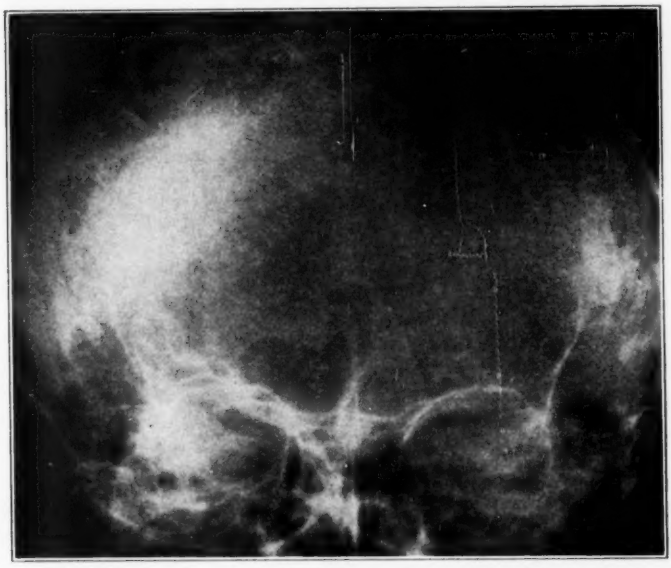

Fig. 2.—Roentgenogram of the skull revealing a linear fracture of 7 cm. in the occipital bone, without fragmentation or depression. The orbits were intact, as were the walls of the maxillary sinuses and the zygomas.

was 160 mm. of water; there were 3 cells per cubic millimeter, and the Pandy test gave a 4 plus reaction for globulin. Protein nitrogen measured 9.8 mg. and total proteins 61.3 mg., per hundred cubic centimeters; the colloidal gold curve was 11112211000, and the gum mastic curve was 3322111000. Diagnostic and exclusion Kline tests gave negative reactions. The orbit was probed with a trocar superonasally in the hope of locating and evacuating an abscess, but without success. On the seventh hospital day, the orbital edema showed no improvement, the cornea was clear but vision had become greatly diminished. The vitreous had become too cloudy to permit visualization of the fundus. On the eighth hospital day, there was no light perception in the left eye.

For the next month the patient was maintained on intermittent therapy with combined penicillin and sulfadiazine. In all, 8,470,000 units of penicillin and 179 Gm. of sulfadiazine were given. Each time that chemotherapy was discontinued the temperature became somewhat elevated; when chemotherapy was reinstituted, the patient again became afebrile. The orbital edema was slow to recede. On several occasions the orbit was incised in different quadrants and probed in search of pus, but none was found. Although the media cleared sufficiently to permit visualization of the fundus, light perception did not return. The disk became a pale lemon yellow with hazy borders and glial proliferation along the large veins. On the thirty-ninth hospital day, the patient was discharged from the hospital with instructions to continue taking 1 Gm. of sulfadiazine by mouth four times a day. All therapy was discontinued after twelve days (approximately two months after the injury), at which time the eye was still completely immobile and the disk pale, with scattered hemorrhages throughout the fundus, and an indurated tongue of conjunctiva still prolapsed through the palpebral fissure.

Three months after the onset, there was some return of mobility of the extraocular muscles of the left eye (30 degrees in vertical range and 20 degrees

Fig. 3.—Residual ptosis a year after the onset. See text for description of fundus.

in horizontal range); muscular recovery appeared to be general, rather than localized to specific muscles, muscle groups or nerves. Four months after the onset the mobility had increased somewhat more, the pupil was still fixed at a diameter of 3.5 mm. and did not react to any stimulus, either directly or consensually. The disk was yellow white with glial proliferation along the great veins. There were scattered deep hemorrhages with a few strands of proliferating retinitis. The arteries were almost completely invisible; there was only a faint thread of blood in the veins. Beyond the first branching of the superior temporal vein, the vein was completely covered with creamy yellow exudate. There was still no perception of light, and some conjunctival edema persisted. Residual ptosis of the left lid remained.

One year after the onset there was still mild ptosis, as seen in figure 3. The pupil was 3 mm. in diameter and did not react to light directly or consensually. From the central position the left eye moved 30 degrees laterally, 20 degrees nasally, 30 degrees upward and 35 degrees downward. The disk was pale grayish yellow and sharp in outline. The arteries were practically empty and carried only a faint thread of blood. The veins were empty, sheathed and almost free of blood, many appearing only as ghosts of vessels. There were

mobilization of pigment and stippling in the macula, and lesser stippling in peripheral areas of the fundus. There was increased prominence of the choroidal pattern secondary to retinal atrophy, as well as moderate choroidal sclerosis temporal to the macula.

COMMENT

This case differed from the usual septic thrombosis in several ways. The onset was insidious, the full picture requiring over three weeks to develop. The course was only mildly febrile, as compared with the usual septic type. The cause was obscure until roentgenograms revealed the presence of skull fracture. Headache, unilateral paralysis of the sixth nerve and faint homolateral conjunctival edema were the only early signs and symptoms. The ophthalmoscopic picture and visual fields were of little value in diagnosis until other signs had already indicated the true nature of the disease. This lack of significance of ophthalmoscopic findings coincided with the experience of Walsh,[4] who stated that "the ophthalmoscopic visible changes are of little importance in establishing the diagnosis. The signs which are observed are engorgement of the retinal veins and low grade papilledema, but these changes appear later."

The fact that this patient survived rather than succumbed to his disease is of more than passing note. With the advent of chemotherapy, the increasing reports of such survivals lend encouragement in the therapy of this grave condition. Reid and McGuckin [5] reported 6 consecutive cases of recovery from thrombosis of the cavernous sinus treated with penicillin and sulfonamide compounds. While the number of reported recoveries is now increasing, the follow-up shows that the condition leaves serious residua. In the case here reported there was complete blindness on the affected side, with internal ophthalmoplegia, partial external ophthalmoplegia and ptosis, still present a year after the illness. Welty [6] reported the case of a 13 year old boy with unilateral septic thrombosis of the cavernous sinus resulting from a furuncle of the ala nasi. Treatment with 36 Gm. of sulfadiazine, 280,000 units of heparin and 3,600,000 units of penicillin brought about a clinical recovery, but the resultant vision was 6/12 and there were residual ptosis and paralysis of the external rectus muscle. Greenish [7] reported

4. Walsh, F. B.: Clinical Neuro-Ophthalmology, Baltimore, Williams & Wilkins Company, 1947.

5. Reid, J. L., and McGuckin, F.: Cavernous Sinus Thrombophlebitis: A Report of Six Consecutive Recoveries, J. Laryng. & Otol. **61**:273, 1946.

6. Welty, R. F.: Bacterial Thrombophlebitis of a Cavernous Sinus with Recovery, Arch. Otolaryng. **43**:70 (Jan.) 1946.

7. Greenish, B. V. I.: Cavernous Sinus Thrombosis, Brit. M. J. **1**:876, 1945.

a case of thrombosis of the cavernous sinus complicating erysipelas which responded to therapy with 34 Gm. of sulfathiazole and 1,320,000 units of penicillin. There were resultant paralysis of the sixth nerve and double vision. Walsh [4] cited the case of a boy with septic thrombosis of the cavernous sinus with pathogens present on blood culture, who continued to have exophthalmos and paralysis of extraocular muscles six months after discharge. His final visual acuity was 20/100, although the factor of keratitis may have contributed to the lowering of the visual acuity.

Circulatory stasis and infection are the two major factors that determine the outcome of thrombosis of the cavernous sinus. The high mortality rates previously observed from this condition were due primarily to the element of infection, which produced death either by direct extension, through the development of meningitis, or by promotion of further thrombosis and the dissemination of septic emboli. When the responsible organisms are sensitive to chemotherapy (and for the most part they are), the combined use of penicillin and sulfonamide derivatives promotes recovery from the infectious process. Despite the rapid development of a localizing barrier of chemotherapy, however, it may require considerable time for infection deep within the thrombus to be eradicated. Such foci may light up again if chemotherapy is prematurely discontinued, and even with the infection completely sterilized it requires weeks for canalization of the thrombus to take place. Almost the entire venous drainage of the orbit empties into the cavernous sinus; collateral drainage is practically nonexistent. Thus, obstruction of the cavernous sinus produces absolute orbital stasis and edema, which lead to severe damage of the optic and other cranial nerves and of the retinal elements. While other structures of the orbit and the wall of the sinus may survive a prolonged cessation of circulation, the cranial nerves and retina are highly susceptible to injury, and their recovery is generally incomplete. Varying degrees of blindness and ophthalmoplegia are the inevitable results.

Early institution of anticoagulant therapy to maintain circulation in cases of incomplete thrombosis may be of value. Even in complete thrombosis it may stop further longitudinal extension of the thrombus. Heparin and dicumarol® (3,3′-methylene-bis-[4-hydroxycoumarin]) have been so used, with good therapeutic response. The contraindication to anticoagulant therapy is the danger of hemorrhage. In cases of thrombosis arising secondary to infection, in which it is presumed that the danger of hemorrhage is not great, anticoagulant therapy may well minimize damage to cranial nerves and preserve vision. In the case

here reported in which the cause was traumatic, and with the presence of a long fracture of the skull, the risk of hemorrhage was considered too great to use anticoagulants.

In the light of this report, and the many others that are appearing on chemotherapy in cavernous sinus thrombosis, we may safely adopt new concepts of the incidence of mortality in this disease. The rare survival previously noted is now the usual and expected outcome. However, the residua are still severe enough to warrant concern. Early institution of combined penicillin and sulfonamide therapy with the addition of anticoagulants (unless contraindicated) may favor more complete recovery.

922 Keith Building.

HERPES ZOSTER OPHTHALMICUS SINE ERUPTIONE

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IN AN exhaustive ophthalmologic review of herpes zoster ophthalmicus, published in the ARCHIVES, Edgerton [1] wrote:

> Cases of zoster without eruption are exceptional, although Lederer in 1900, reported such cases. . . . A typical zoster without eruption but with neuralgia may occur. . . . Ahlström, in 1904, described an unusual case in which corneal zoster was the only form of involvement of the fifth nerve in the course of zoster of the lumbar plexus. Von Hoffmann, in 1879, described a similar case, but without the cutaneous eruption.[2]

Although I have not had recourse to all the articles cited, I have the definite impression that herpes zoster ophthalmicus sine eruptione is not a common disorder.

In three years of ophthalmologic practice since World War II, I have encountered 5 cases of herpes zoster ophthalmicus—3 with eruption and 2 without. Brief reports of the 2 cases without eruption, with notes of comparison, follow.

REPORT OF CASES

CASE 1.—A white man aged 66, a watchman, with hypertensive cardiovascular disease, who eventually succumbed to this condition, complained of bitter neuralgic pains over, in and around his right eye. The pain radiated back into the occiput and down into the right malar region and the right side of the nose. The onset was sudden. There were no prodromal symptoms except malaise. His other complaints were tearing and photophobia of the right eye. His past history was noncontributory except for the hypertensive cardiovascular disease.

The patient had bilateral compound hypermetropic astigmatism with presbyopia, and vision was easily corrected to normal for both near and far in each eye. There were obvious tearing, photophobia and blepharospasm of the right eye. This eye was very slightly exophthalmic. On first examination, all other findings were normal, including results of the usual laboratory tests and the usual ophthalmologic survey with studies of the visual fields and determination

1. Edgerton, A.: Herpes Zoster Ophthalmicus, Arch. Ophth. **34**:40-62 (July); 114-153 (Aug.) 1945.

2. Citations in the bibliography were: Lederer, R.: Herpes zoster ophthalmicus ohne Hautaffection, Centralbl. f. prakt. Augenh. **24**:232, 1900. Ahlström, G.: Några komplikationer vid herpes zoster ophthalmicus, Nord. med (Hygiea) **4**:920, 1904. von Hoffmann: Herpes zoster ophthalmicus, Tag. d. Versamml. deutsch. Natur. u. Aèrzte **52**:337, 1879; Med.-Chir. Centralbl. **15**:484, 1880.

of tension. Although reflexes were normal, anisocoria appeared in a few days, the right pupil being corectatic. Subsequently, the cornea of the right eye lost its luster, and there developed moderate inflammation of the right preauricular lymph nodes, which subsided in a week. Later there were swelling and infiltration of the corneal stroma with folds in Bowman's and Descemet's membranes and other signs of involvement of the anterior segment, an aqueous flare, cells in the anterior chamber and edema of the iris. There were corneal anesthesia and anesthesia in the distribution of the three branches of the ophthalmic division of the fifth cranial nerve. The left eye was uninvolved except that ophthalmoscopic study early revealed bilateral angiosclerosis grade 2 in each eye.

The course was stormy, and the condition was not responsive to therapy of any sort; although the mydriasis persisted in the right eye, later atropinization made it impossible to assess further pupillary changes. A diagnosis of herpes zoster ophthalmicus sine eruptione was made, since at no time did a cutaneous rash appear. The corneal lesion finally involved and broke through the epithelium, the ulceration proving as refractive to therapy as the pain and involvement of the anterior segment. Smears and cultures of corneal material were not helpful. Although no virus was cultured, the cytologic picture supported at first a virus etiology, but later a hemolytic staphylococcus appeared as a secondary invader. After two weeks, there was sudden complete paralysis of the third nerve; the ptosis seemed to help the corneal condition for time; but, with partial recovery after a few months, the corneal leukoma, which was still partially ulcerated and now presented slight superficial vascularization, flared up. A median tarsorrhaphy was therefore done. Meanwhile, the ocular pain had abated, as well as the neuralgia and anesthesia, the latter clearing first. After the second week of closure of the lids, terrific ocular pain recurred but was then localized. Freeing of the lids disclosed a partially healed cornea but a glaucomatous eye that no longer had even light perception. The pupil was still dilated and was sluggishly mobile, and a complicated cataract was present.

From then until enucleation there were periods of pain and ulceration and periods without these symptoms, but the two were not necessarily correlated. Residual ptosis and slight exophthalmos remained. After retrobulbar injections of alcohol there was freedom from pain for only a few weeks, and the recurrence necessitated removal of the eyes. The patient's ocular condition was comfortable from then until his death.

Case 2.—Since many features of this case parallel those of the first case, only the salient ones will be mentioned.

A white man aged 50, a truckman, whose past medical history was normal, presented early complaints and signs identical with those in case 1; but later the pupil of his right (involved) eye became miotic and all attempts to dilate it were futile. The corneal picture and the changes in the anterior segment were similar. The picture in the fundus, however, was of no importance. There was suggested enophthalmos of the right eye, and he likewise had a compound hypermetropic astigmatism with presbyopia in each eye. Correction, which was done early, allowed normal vision for near and far in each eye. There was a similar early homolateral involvement of the preauricular lymph nodes, which subsided in a week. However, complete paralysis of the third nerve did not develop in this case; instead, only the superior branch was involved with weakening of the levator and superior rectus muscles. Recovery of this paralysis was complete in two weeks. The corneal course, although stormy, finally ended in recovery, with a dense leukoma, as in case 1, and superficial vascularization. There were no

eventual synechias or complicated cataract, but vision was reduced to 20/200 for near and far with the best correction. The anesthesia disappeared before pain, as in case 1, and no therapy seemed effective. Throughout the course of disease the tension in the involved eye was lower than that in the healthy eye, but before discharge it approximated that of its fellow eye. There was no residual ptosis or difference in position of the eyes, and a relatively normal pupil finally resulted.

Some of the interesting observations in these 2 cases are compared in the accompanying table. The corneal lesions prevented extensive studies of the fundus.

Herpes Zoster Ophthalmicus Sine Eruptione

	Case 1	Case 2
Prodromal symptoms	Malaise	Malaise
Symptoms of syndrome	Herpes zoster ophthalmicus but no rash	Herpes zoster ophthalmicus but no rash
Homolateral involvement of preauricular lymph nodes	Present early and subsided in one week despite clinical course	Present early and subsided in one week despite clinical course
Side involved	Right	Right
Corneal anesthesia	+	+
Anesthesia of all three branches of the ophthalmic division of the fifth cranial nerve	+	+
Exophthalmos	+	Possibly enophthalmos
Disciform keratitis with ulceration and, later, superficial vascularization	+	+
Involvement of anterior segment with edematous iris	+	+
Pupil	Mydriasis	Miosis throughout
Involvement of third cranial nerve	Paralysis of entire third cranial nerve with delayed recovery (3 mo.)	Paralysis of superior branch with rapid recovery (2 wk.)
Skin	No rash	No rash
Tension	Normal at first; elevated later	Low at first; approached that of fellow eye later
Course and response to therapy	No response to therapy; anesthesia disappeared before pain; stormy course	No response to therapy; anesthesia disappeared before pain; stormy course
Final result	Slight residual ptosis; recurrently ulcerated leukoma; complicated cataract; no synechias; sluggishly mobile pupil; absolute glaucoma with enucleation	No residual ptosis; leukoma; lens normal; no synechias; relatively normal pupil; vision 20/200 for far and near

COMMENT

These 2 cases of herpes zoster ophthalmicus sine eruptione are presented, since such cases are likely to be commoner than reports indicate. As would be expected, the diagnoses in these cases were made on a clinical basis.

There are two main types of herpes zoster ophthalmicus irrespective of the presence of a rash: the epidemic and the symptomatic. The latter is stated to be the commoner and is said to be due to a vascular, toxic, inflammatory, traumatic or neoplastic disorder. The epidemic, or primary, type is thought by many investigators to be due to a virus, but there is no unanimity of opinion about this. Those who support the

virus theory believe that the virus is causative with or without predisposing factors, such as trauma, debility, intercurrent fevers and infections and physical factors, and that this virus is related to the virus of herpes simplex and varicella. However, the viruses of herpes simplex and herpes zoster differ immunologically and in many other ways, but both viruses are believed to spread along the nerves, and changes from both have been observed in the gasserian ganglion. An eruption with a zoster-like distribution has been produced by inoculation with the virus of herpes simplex, but other differences were apparent; all in all, there is little to support the idea that the two viruses are closely related. The elementary bodies of the herpes zoster virus are demonstrable in properly stained films of vesicular fluid and are agglutinable. The intranuclear inclusion bodies are acidophilic. The virus is grown with difficulty, and it is said to produce a potent and lasting immunity. These observations make one wonder whether the recurrent herpes zoster does not have a multiple causation or whether there are not many strains of a basic virus type, or a difference between laboratory and in vivo findings.

The etiologic factor in the present cases is not definitely known. The condition in case 1 may have been on a vascular basis, since the patient had hypertensive vascular disease and died of cardiac failure. But all that can be stated is only speculative. At any rate, the course was pernicious in both cases, certainly worse in the case in which enucleation was finally necessary, but treatment did not seem of much avail in either. Unfortunately, suitable blood from a patient convalescing from herpes zoster was not available, nor was convalescent serum used. Although I have found diphtheria antitoxin of some value in cases of vesicular eruptions of the lid, possibly owing to the herpes simplex virus, here it, too, was ineffective.

The clinical picture in each case was that of anesthesia of the fifth cranial nerve, ophthalmic branch, and disciform keratitis with later edema and loss of epithelium, and resultant superficial vascularization, but never deep vascularization. No vesicles were observed at any time, but the iris showed edema in each case with mydriasis in one case and miosis in the other. No synechias were present in either case. Only the third cranial nerve was involved in each case, and only a branch in case 2. The slight exophthalmos with pupillary enlargement in case 1 leads one to wonder whether stimulation of the sympathetic fibers with depression of the parasympathetic nerve fibers was not a factor. The physiology of these mechanisms is more complicated than some authors would have one believe, for the anatomic ramifications of pupillonerve fibers are manifold. A blind eye with a mobile but enlarged pupil adds to the unusualness of the case. The eye in case 2 seemed slightly enophthalmic, and this with ptosis and miosis again

might be interpreted as depression of the sympathetic nerve supply. One might further speculate as to the neurologic basis of the high tension in the one case and of the subnormal to normal tension in the other. In Edgerton's article such factors are discussed with clarity.

The rarity of cases of this condition, or at least of the reports of such cases, warrants the recording of any case, even though nothing of any therapeutic value is to be gained.

321 East Front Street.

NOTE.—The following pathologic report, by Dr. H. C. Wilder, on the eye enucleated in case 1 is appended, since it was not available at the time of the original writing. It is interesting in that it supports the vascular theory as a possible cause of the original disturbance, as well as its subsequent accompanying glaucoma.

Microscopic Study.—The conjunctiva was hemorrhagic, and its vessels were congested. The corneal epithelium was irregular over a vascular scar, which involved the outer central lamellas. In this region Bowman's membrane was absent. Peripherally there were desquamation of corneal epithelium and a thin pannus. Clumps of mononuclear cells clung to the posterior surface of the cornea, and there was moderate loss of endothelial nuclei. There were precipitated proteins in the anterior chamber. The corneoscleral trabeculae were sclerotic, and Schlemm's canal was at least partially obliterated. Pigment was present in the narrowed intertrabecular spaces. The anterior surface of the atrophic iris was vascularized. Slight vascularization was to be seen in the filtration angle, but there was no actual anterior synechia. The ciliary body was somewhat atrophic. The vascular layer was edematous and contained hemorrhage. The processes were hyalinized and their vessels congested. The choroid was thin and contained a few small patches of lymphocytes. The choroidal arteries were sclerosed and the choroidal veins congested. There were multiple retinal hemorrhages and sclerosis of retinal arteries. The retinal ganglion cells had disappeared. The nerve fiber layer was atrophic, and the outer nuclear and outer plexiform layers were thin. There is advanced retinal atrophy in the macular region. Here the rods and cones had disappeared, and there was considerable loss of normal architecture. The cupped optic disk contained sclerotic arteries. The lamina cribrosa was depressed, and behind it the optic nerve had undergone cavernous atrophy on the temporal side. There was lymphocytic infiltration around episcleral and adherent orbital veins. Although most of the lens had been lost in the technical procedure, there appeared to be early degenerative changes in the subcapsular fibers at the equator and posteriorly.

Diagnosis.—The diagnosis was central corneal scar; episcleritis; mild chronic uveitis; arteriosclerosis, and hemorrhagic glaucoma, compatible with occlusion of the central retinal vein or large tributaries in or around the nerve head.

CORNEAL TRANSPLANTATION

I. Visual and Cosmetic Results

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SYRACUSE, N. Y.

"NEW EYES for Old—Corneal Transplants" was the spectacular title of an article published in *Hygeia* last year.[1] According to this article, corneal transplantation is no longer experimental but has been proved in several thousand operations, and the factors making for its success or failure are well established. It also stated that the technic has been improved to the point where it may be undertaken with the same degree of confidence as may any other major operation on the eye. Publicity of this type has misled the public into believing that corneal transplants are a cure for total blindness and that new eyes can be transplanted to replace diseased ones. It is unfortunate that this article appeared in *Hygeia,* a magazine designed for the layman and approved by the medical profession.

The layman is not alone in his lack of knowledge on the subject of corneal transplantation. Many members of the medical profession, including even some ophthalmologists, have been confused by the recent wave of optimistic literature on corneal transplants. One of the principal causes of this optimism has been the tremendous, but unfortunate, publicity surrounding the operation for corneal transplantation during the past decade, particularly in the United States. The force of this publicity has been such that surgeons have been reluctant to publish anything but successful cases. Few failures can be found recorded in the literature. The publication of isolated successful results has been especially misleading, both in professional journals and in the lay press. The point was finally reached where even the more experienced ophthalmologists read so much about successful corneal transplants that they began to believe what they read. The truth is that the important facts about this operation have not been revealed. Among the unanswered questions are these: What are the indications for a corneal transplantation? What is the percentage of successful results? What is the standard of success, transparency of the graft or improvement in vision? What are the complications following this operation? How do these complications affect the final result? The answers to these

1. Fine, M.: New Eyes for Old: Corneal Transplants, Hygeia **25**:780-781, 813-814, 1947.

questions cannot be learned in the study of successful cases alone. Complete series of cases, with pertinent data on all cases in which the procedure was attempted, both successes and failures, are needed to evaluate properly a new operation. No such series of corneal transplantations of significant size can be found in the existing literature.

It has been my privilege to review the clinical records of all ward cases of corneal transplantation occurring at the Presbyterian Hospital in the past fifteen years and to see many of the patients after operation in the Vanderbilt Clinic. The thorough preoperative work-up and the long postoperative follow-up of most of these cases make the series very favorable for evaluation. The purpose of the present paper is an analysis of the visual and cosmetic results in this series of cases.

REVIEW OF LITERATURE

Although the literature contains many papers on corneal transplantation, few authors have had experience with more than a dozen operations. The notable exceptions are Elschnig, Filatov, Thomas and Castroviejo, each of whom has reported a considerable number of keratoplasties. Perhaps one should also mention Fuchs,[2] who described his experience with 30 corneal transplantations in 1894, and Franceschetti, who has recently reported two series of operations.

Elschnig and Gradle[3] first discussed the results of corneal transplants in 1923, when they reported 9 permanently clear grafts in a series of 93 operations performed in Elschnig's clinic. Later (1930) Elschnig[4] reviewed his entire experience with the operation, covering a period of over twenty years. A total of 174 transplantations were performed in Elschnig's clinic during that period, and all but 7 of these operations were done by Elschnig himself. Thirty-five of the 174 operations were performed for purely cosmetic reasons, and the results in these cases were uniformly poor. Of the remaining 139 transplantations performed for visual purposes, Elschnig reported improved vision in 65 cases (46.7 per cent), opaque grafts in 51 cases (36.7 per cent) and dislocation of the graft in 23 cases (16.6 per cent). He concluded that one should refuse to do the operation in cases of aphakia, on patients under 14 years of age, in eyes with wide anterior synechias and in the presence of glaucoma.

In 1935 Filatov[5] published his results in 96 corneal transplantations performed between 1923 and 1932. He obtained clear grafts in

2. Fuchs, E.: Ueber Keratoplastik, Wien. klin. Wchnschr. **7**:843-845, 1894.

3. Elschnig, A., and Gradle, H. S.: History of Keratoplastic Operations to Date, Am. J. Ophth. **6**:998-999 (Dec.) 1923.

4. Elschnig, A.: Keratoplasty, Arch. Ophth. **4**:165-173 (Aug.) 1930.

5. Filatov, V. P.: Transplantation of the Cornea, Arch. Ophth. **13**:321-347 (Feb.) 1935.

14 of this series; in 12 of the 14 cases (12.5 per cent) vision was improved. In 1937 Filatov [6] discussed another series, of 95 operations, performed from 1932 to 1937. He divided his results in this series into four categories, according to the transparency of the grafts: (1) opaque grafts, 46 cases; (2) half-transparent grafts, 27 cases; (3) transparent grafts,[7] 18 cases, and (4) clear grafts with a connective tissue film over the posterior surface, 4 cases. Filatov stated that the percentage of clear grafts in this series was not significant because in 46 cases the condition was hopeless from the beginning (glaucoma, buphthalmos, applanation, atrophy or symblepharon).

In 1937 Thomas [8] summarized his results in 36 corneal transplantations performed between 1930 and 1936. Thomas devised a classification for his results, according to the transparency of the graft, as follows: (1) transparent graft, (2) slight opacity, (3) much opacity, but less than the original, (4) much opacity, but equal to or worse than the original, (5) detached graft and (6) loss of the eye. In his series of 36 operations, there were 5 transparent grafts, 7 grafts with a slight opacity, 9 grafts with much opacity but less than before operation, 14 grafts with much opacity, equal to or less than that before operation, and 1 detached graft. Thomas stated that the results in the first three categories (21 operations, or 58 per cent) were successful.

In 1938 Castroviejo,[9] discussing over 100 corneal transplants performed between 1933 and 1937, reported clear grafts and considerable improvement in visual acuity in over 40 per cent of unselected cases. He found transparent grafts and improved vision in more than 70 per cent of favorable cases. In a summary of more than 150 keratoplasties in 1939, Castroviejo [10] stated that permanently clear grafts and considerable improvement in vision could be expected in more than 90 per cent of suitable cases. Later Castroviejo [11] repeated these impressive

6. Filatov, V. P.: Transplantation of the Cornea from Preserved Cadaver's Eyes, Lancet **1**:1395-1397 (June 12) 1937.

7. Some may question Filatov's definition of a transparent graft. He explained that "transparent graft" meant that the details of the anterior chamber could be clearly made out, at least through part of the transplant, or that there was a good light reflex through the graft.

8. Thomas, J. W. T.: The Results of Corneal Transplantation, Brit. M. J. **1**:114-116 (Jan. 16) 1937.

9. Castroviejo, R.: Results of Corneal Transplantation, Arch. Ophth. **19**:834-835 (May) 1938.

10. Castroviejo, R.: Present Status of Keratoplasty, Arch. Ophth. **22**:114-126 (July) 1939.

11. Castroviejo, R.: (*a*) Keratoplasty; Comments on Technique of Corneal Transplantation. Source and Preservation of Donor's Material. Report of New Instruments, Am. J. Ophth. **24**:1-20 (Jan.), 139-155 (Feb.) 1941. (*b*) Indications and Contraindications for Keratoplasty and Keratectomies, Tr. Am. Ophth. Soc. **43**:324-330, 1945; Am. J. Ophth. **29**:1081-1089 (Sept.) 1946.

figures in relation to even larger series of cases. A number of other ophthalmologists [12] in this country have also been enthusiastic about their results with corneal transplantation.

Some of the recent European reports on corneal transplantation have not been so optimistic. In 1943 Franceschetti and Streiff [13] reported their findings in 50 cases of corneal transplantation as follows: improved vision (20/200 or better) in 16 cases; slightly improved vision in 7 cases; no significant change in vision in 17 cases, and a loss of vision in 10 cases. In 1946 Weve [14] pointed out the dangers of the sensational publicity surrounding the operation in the United States and called attention to the great discrepancies between results reported in America and those reported in Europe. He stated that cases favorable for keratoplasty are rare and that the results are generally not very good. Franceschetti and Doret [15] reported their results in another series, of 45 cases, in 1946, as follows: improved vision (20/200 or better) in 14 eyes; slightly improved vision in 11 eyes; no significant change in vision in 17 eyes, and a loss of vision in 3 eyes. In contrast with these reports, Filatow [16] described a great increase in the number of successful operations when he changed from living cornea to cadaver cornea as donor material. According to his text, he performed a total of 842 corneal transplantations between 1922 and 1941. In 171 operations the donor material was taken from living persons, and in 671 operations, from the cadaver. Successful results were obtained in 24.1 per cent of favorable eyes in the first series and in 66.6 per cent of favorable eyes in the second series (cadaver cornea).

The pertinent data on the results of corneal transplantation from the papers cited in this review are assembled in table 1. There are

12. Fine, M.: Treatment of Keratoconus by Corneal Transplantation, Tr. Pacific Coast Oto-Ophth. Soc. **28**:48-66, 1947. Leahey, B. D.: Corneal Transplantation, New England J. Med. **228**:387-389, 1943. Lordan, J. P.: Ophthalmological Progress: Sight Restoration by Corneal Transplant, California Med. **68**: 90-94, 1948. McKinney, J. W.: Indications for Corneal Transplantation, South. Surgeon **13**:622-625, 1947. Paton, R. T.: Sight Restoration Through Corneal Grafting, Sight-Saving Rev. **15**:3-12, 1945; Evaluation of Results in a Series of Corneal Transplants, Arch. Ophth. **33**:83-85 (Jan.) 1945; Technique and Complications of Keratoplasty, Am. J. Ophth. **30**:1302-1303 (Oct.) 1947; Complications Encountered in Keratoplasty, ibid. **30**:1436-1439 (Nov.) 1947.

13. Franceschetti, A., and Streiff, E. B.: Résultats fonctionnels dans 50 cas de kératoplastie avec quelques détails sur la technique opératoire, Schweiz. med. Wchnschr. **73**:1371-1374, 1943.

14. Weve, H. J. M.: Clinical Significance of Corneal Transplantation, Nederl. tijdschr. v. geneesk. **90**:1768-1774, 1946.

15. Franceschetti, A., and Doret, M.: Technique et résultats des greffes de la cornée, Bull. et mém. Soc. franç. d'opht. **59**:83-95, 1940-1946.

16. Filatov, V. P.: Optical Transplantation of the Cornea and Tissue Therapy, Moscow, Markomzdrav, State Publishers of Medical Literature, 1945; reviewed, Arch. Ophth. **37**:698-700 (May) 1947.

many obvious voids. Elschnig and Filatov gave the number of cases in which vision was improved but did not mention their standard of improved vision. Both these surgeons failed to discuss the visual results in the remainder of their series. Thomas discussed transparency of the graft only and paid little attention to visual results. Castroviejo cited no exact figures but gave only approximate numbers of cases and approximate percentages of successful results. He discussed his percentage of successful results in favorable eyes without revealing the number of favorable eyes. Castroviejo quoted the same figure for clear grafts and for eyes with improved vision, lending the

TABLE 1.—*Published Results of Corneal Transplantation*

Author	Number of Cases	Number with Improved Vision	Number of Clear Grafts	Number of Opaque Grafts
Elschnig, 1930	139	65, or 46.7%	32, or 23.0% (Partially clear: 33, or 23.7%)	51, or 36.7% (Dislocated graft: 23, or 16.6)%
Filatov, 1935	96	12, or 12.5%	14, or 14.6%	.....
Filatov, 1937	96	.....	18, or 18.9% (Partially clear: 21, or 22.1%)	46, or 48.4%
Thomas, 1937	36	.....	5, or 13.9% (Partially clear: 16, or 44.4%)	14, or 38.9% (Dislocated graft: 1, or 2.8%)
Castroviejo, 1938	Over 100	Over 40% in unselected cases Over 70% in favorable cases		.....
Castroviejo, 1939	Over 150	Over 90% in favorable eyes		.....
Franceschetti and Streiff, 1943	50	16, or 32% (Slightly improved: 7, or 14%)	.....	.....
Filatov, 1945	171 Living cornea	24.1% in favorable eyes	.....	.....
	671 Cadaver cornea	66.6% in favorable eyes	.....	.....
Franceschetti and Doret, 1946	45	14, or 31% (Slightly improved: 11, or 24%)	.....	.....

impression that all clear grafts lead to improved vision. Franceschetti and his co-authors alone have reported all the visual results, good and bad, in a complete series of operations. One important factor in the evaluation of this operation, namely, the length of the follow-up period, has been overlooked by all these authors.

RECENT SYMPOSIUM

A sober note was finally sounded in this country in 1947, when Post [17] called attention to the need for a critical analysis of corneal transplantation. Soon after, the American Academy of Ophthalmology and Otolaryngology arranged a symposium on this subject, with one

17. Post, L. T.: Eye Banks, Editorial, Am. J. Ophth. **30**:920-922 (July) 1947.

paper on the results of the operation. The plan was to collect a large enough number of case reports so that the results would be statistically significant. Representatives of seven ophthalmic clinics assembled the data on corneal transplantations performed in their hospitals and forwarded the information to one institution for transcription to punch cards and statistical analysis. The figures presented by the statistical machines were then interpreted and the report[18] compiled was that delivered at the 1947 meeting of the society.

Although it is generally believed that this statistical study worked well, I do not subscribe to that opinion. Too much emphasis was placed on statistics, and the result was a report with too many statistics and too few facts. In addition to statistical confusion, the report of the symposium failed for the following reasons:

Postoperative Selection of Cases for Analysis.—The authority of this cooperative analysis was greatly weakened by the exclusion of a considerable number of cases from evaluation. Moreover, the number of cases so excluded varied in the different analyses. The ensuing variability in the strength of the series is demonstrated by the totals in the five tables in the report; tables 1 to 5 contain, respectively, 362, 367, 357, 331 and 253 cases. A striking example of exclusion of unfavorable cases is seen in the analysis of visual results, in which 128 cases were excluded on the basis of preoperative cataract, glaucoma, nystagmus, amblyopia ex anopsia and pathologic condition of the fundus. One might miss lesions in the fundus in these cases, but how can one disclaim preoperative knowledge of cataract, glaucoma, nystagmus or squint in over one third of the series? Again, when the cases were divided into prognostic groups, 79 cases were placed in group 1 (the very favorable group). However, when the visual results were discussed according to prognosis (on the next page), only 58 cases from this most favorable group qualified for analysis!

Misleading Use of Percentages.—All results and conclusions in the report were translated into percentages, regardless of the size of the group being analyzed; most of these percentages had little statistical significance. A percentage has little meaning when the sample from which it is derived is much less than 100. For example, in this report the results of corneal transplantation were judged as good in cases of aphakia, because 42.8 per cent of the grafts in such cases remained clear. Actually, there were only 7 cases of aphakia and 3 clear grafts; a change in 1 graft would have lowered this percentage to 28 per cent or raised it to 57 per cent. Similarly, these dubious percentages were used to compare results in diagnostic groups varying widely in strength

18. Owens, W. C., and others: Symposium on Corneal Transplantation: V. Results, Tr. Am. Acad. Ophth. **52**:341-346 (March-April) 1948; Am. J. Ophth. **31**:1394-1399 (Nov.) 1948.

(as small as 13 for active keratitis and as large as 141 for nonspecific inflammatory scar), and the percentages were then treated as though of equal statistical significance. Further, all percentages in the report were carried to tenths of a per cent, regardless of the size of the group. These fractions were arithmetical by-products, without meaning, and tended only to increase the apparent significance of already questionable percentages.

Clear Graft as the Standard of Success.—The report admitted that the most important consideration in evaluating the result of a corneal transplantation is improvement in vision, but stated that mere comparison of preoperative and postoperative vision is unsatisfactory because some patients have preoperative cataract, glaucoma, nystagmus, amblyopia ex anopsia or lesions of the fundus. Changes in visual acuity as a measure of success were also criticized on the basis that slight changes may be due to increased effort or to familiarity with the test objects. These arguments are difficult to follow. To repeat, an ophthalmologist should generally be aware of the aforementioned conditions before operation, and the results of operation performed in spite of these complications must be faced, just as in a review of cataract extractions. It is true that slight changes in visual acuity are often meaningless. However, the very fact that visual acuity is recorded by means of a numerical scale enables one to eliminate small changes in acuity and makes possible a grading of the significant changes that is quite impossible with transparency of the graft. There are always "slightly cloudy," "hazy" and "almost clear" grafts that defy classification as to transparency. More important, however, is the fact that clear grafts do not necessarily mean a better eye; transparent grafts that bulge enough to prevent useful vision are not uncommon. Except in the unlikely event of transplantation for cosmetic reasons, the only logical index of success for this operation is improvement in vision.

Paucity of Reported Visual Results.—No visual results were reported for the whole, unselected series; only the visual outcome in selected fractions of the series received recognition. In one selected group only the number of cases in which visual acuity of 20/20 to 20/30 was obtained and the number of cases in which all light perception was lost were given. In another selected group, the number of cases in which visual acuity was 20/100 or better was given. There was a comparatively detailed discussion of the visual results in the cases with preoperative vision of 20/100 or better; the conclusion that corneal transplantation is not warranted in patients with such acuity was naïve. The section on visual results according to prognosis contained so many statistical and arithmetical inconsistencies that the value of the conclusions drawn is difficult to assess. The most important defect in the

symposium, however, was the omission of an analysis of the visual results in an unselected series.[19]

Glasses.—The report contained no reference to optical correction, either preoperative or postoperative. One would like to know whether the visual acuity, before and after operation, was recorded with or without glasses. In the cases with improved vision following the operation, one would like to know the nature of the refraction.

Brevity of Follow-Up Period.—The four month period of postoperative observation was short. Six months should elapse before the outcome of a corneal transplantation is at all certain, and successful grafts at the end of six months occasionally become failures after a year or more.

Summary.—This cooperative effort to analyze the results of several series of corneal transplantations failed in the same manner that the reports of so many individual series have failed, namely, in the exclusion of unfavorable cases. While admitting that the goal of corneal transplantation is improvement in vision, the authors of this report judged their results on the basis of clarity of the graft. Finally, this statistical analysis contained too many figures of little statistical significance and showed little correlation of its various subdivisions.

PRESENT SURVEY

In view of the inconclusive nature of the results of the symposium on corneal transplantation, I have again reviewed the records of such operations performed in the ward services at the Institute of Ophthalmology of the Columbia University–Presbyterian Hospital Medical Center. Most of these operations were included in the series discussed in the symposium.[20] The postoperative result has now been observed

19. Although the visual result in the unselected series was not given in the symposium, it may be estimated with fair accuracy from the data in table 5 of that report.[18] Presuming only that all cases in which vision was improved were included in this table, one may conclude that in the unselected series of 381 cases (1) better than 20/200 visual acuity was obtained in 91 cases, or 24 per cent; (2) slight improvement, but not to better than 20/200, was obtained in 19 cases, or 5 per cent; (3) vision remained better than 20/200 but was unchanged in 3 cases, or 1 per cent; (4) loss of vision to 20/200 or less occurred in 85 cases, or 22 per cent; (5) vision remained 20/200 or less but was unchanged in 55 cases, or 14 per cent, and (6) the visual result was not given but was 20/200 or less in 128 cases, or 34 per cent. More briefly, the postoperative visual acuity was better than 20/200 in 94 cases, or 25 per cent of the series, and was 20/200 or less in 287 cases, or 75 per cent of the series.

20. At that time, the data from the case histories were collected and submitted to the chairman of the committee by Dr. J. A. C. Wadsworth and me. We did not participate, however, in the evaluation of the results or the preparation of the paper read at the meeting of the Academy.

for an additional eighteen months in most cases, and the operations performed during 1947 have been included. In the present review, particular attention is given to the preoperative and the postoperative visual acuity. The best visual acuity, with or without correction, is recorded and the refraction noted. Because the significance of the reported results increases with the length of observation, the follow-up period for each operation is included. The degree of transparency of the graft is included for purposes of comparison.

Before the results in a series of corneal transplantations can be evaluated, the criterion of a successful operation must be determined. Excluding transplantation for cosmetic reasons (a questionable procedure), it must be granted that the goal of the operation is improved function and that clarity of the transplant is but one of the anatomic prerequisites to success, of no more importance than normal curvature of the cornea or absence of anterior synechias. Admitting that improvement in vision is the measure of a good result, it still remains to specify the necessary amount of improvement. In the symposium, changes in visual acuity from light perception to perception of hand movements, from perception of hand movements to the 1/200–10/200 category and from the 1/200–10/200 to the 11/200–20/200 category were tabulated under improved vision. These are very small changes in visual efficiency, however, and the recording of visual acuity in these low categories is subject to considerable error, particularly when both the physician and the patient are trying to show postoperative improvement. Moreover, such changes are not significant so far as industrial vision is concerned. From a practical point of view, then, it appears necessary to decide what constitutes a significant change in vision and to select some point on the scale of visual acuity to serve as a standard of minimum acuity for a successful result. It is suggested that significant changes in visual acuity be arbitrarily limited to changes of more than one step in the visual scale. This can be applied to both increases and decreases in visual acuity. Inasmuch as 20/200 is commonly accepted as the threshold for industrial blindness, it is suggested that a successful result after a corneal transplantation should require improvement in visual acuity to better than 20/200. This will furnish a convenient yardstick for success, acceptable and known to all physicians, from which other graduations of success or failure can easily be computed.

STANDARDS FOR EVALUATION OF RESULTS

Employing these two arbitrary provisions, I have devised the following standards for the evaluation of this series of corneal transplantations:

Improved Vision (successful result).—Vision is classified as improved when the final visual acuity is (1) better than 20/200 and (2) better than the preoperative visual acuity by more than one step

in the acuity scale. Increases of more than one step in the visual scale when the final result is 20/200 or less are classified as unchanged.[21]

Unchanged Vision (not improved, or no significant change).—Vision is said to be unchanged when the final visual acuity fails to differ from the preoperative visual acuity by more than one step in the visual scale, in either direction, and this pertains whether the final visual acuity is better or worse than 20/200. This category also includes those eyes in which there is an increase of more than one step in the visual scale but the final result is 20/200 or less.

Loss of Vision.—There is said to be a loss of vision when there is a decrease in visual acuity of more than one step in the visual scale, whether the final result is better or worse than 20/200. This group also includes eyes showing a change from light perception to no light perception.

ANALYSIS OF RESULTS

A total of 182 corneal transplantations were performed in the ward services at the Institute of Ophthalmology between 1933 and 1947. Seventeen operations were excluded because the follow-up period was shorter than six months.[22] The remaining 165 operations, performed on 110 patients, form the basis of this report. These operations are divided into eight groups, according to diagnosis, and the pertinent data on results are tabulated by group. The operations on eyes that had already experienced corneal transplantation were placed in a separate group and called secondary transplantations. This appeared appropriate in most instances because the pathologic condition of the cornea at the time of the secondary operation varied so greatly from the original lesion. The numbers in the first column in the tables refer to operations, not to patients or to eyes. In each group, the operations are arranged in chronologic order. The clinic number, age, and sex, serve to identify the patient. The visual acuity given is the best available to that eye, either with or without correction. In a few instances in which visual acuity was recorded with a contact lens, the lens was well tolerated. In a number of cases of keratoconus, vision was improved with contact lenses, but the patient did not tolerate the lenses; in those cases the

21. Some will disagree with the exclusion of cases of this category from the group with improved vision. If the bulk of opinion approves the objection, the classification can be modified to include these cases as another group or subgroup (slight improvement). The number of cases eligible for such a group, however, does not appear to substantiate its necessity; in the present series of 165 cases, only 5 (table 10) would fall into that category.

22. Cases in which the follow-up was definitely terminated, as by enucleation or a second corneal transplantation, were included in the analysis, regardless of the follow-up period.

visual acuity with the contact lenses was disregarded. The length of the follow-up period in the seventh column is given to the nearest whole month. The comments under "Clarity of Graft" are taken from the patient's record. The last column ("Final Visual Acuity") is my evaluation of the success of the operation, according to the standards already outlined.

Keratoconus.—Thirty-five corneal transplantations were performed on 26 patients with conical cornea. The results in this group of operations are shown in table 2. Preoperative visual acuity was better than 20/200 in 7 eyes and varied from counting fingers to 20/200 in the remaining 28 eyes. Postoperative visual acuity was improved (better than 20/200) in 10 eyes, unchanged (no significant change) in 13 eyes and decreased in 12 eyes. Total loss of vision occurred in 1 instance (operation 25). All 10 eyes with improved vision had preoperative vision of 20/200 or less. Eight of these 10 eyes required high minus correction after operation to obtain the improved visual acuity; the remaining 2 eyes showed moderately high hypermetropia and mixed astigmatism. Only 1 of the 10 eyes attained better than 20/200 visual acuity without correction (operation 8). Vision was not improved in any of the 7 eyes with better than 20/200 visual acuity before operation; 6 eyes in this group showed loss of vision, and the remaining eye showed no significant change.

With respect to transparency of the graft, 18 eyes showed permanently clear transplants (average follow-up period, forty-seven months); 6 eyes, cloudy grafts, and 11 eyes, opaque grafts. The difference between the number of clear grafts and the number of eyes with improved vision is noteworthy. Only 9 of the eyes with clear transplants showed improved vision. In 1 eye (operation 35) visual acuity was improved in the presence of a cloudy graft. Figure 1 is a photograph, taken nine years after operation, of a clear graft (operation 4) without improvement in vision.

The follow-up period for the group averaged 32.5 months. The difference between the length of the follow-up period for operation 1 (one hundred and thirty-four months) and that for operation 2 (ten months) on the same patient occurred because operation 2 was followed by a second transplantation ten months later. A second transplantation also explains the brevity of the follow-up period for 7 other operations in this group.

Eleven of the patients with conical cornea had multiple operations. Nine patients had a corneal transplantation on each eye. Four of these patients with bilateral transplantations and 2 patients with unilateral grafts had secondary corneal transplantations. In the group with bilateral grafts, 1 patient obtained improved visual acuity in both eyes;

TABLE 2.—*Results of Corneal Transplantation in Cases of Keratoconus*

Year	Operation No.	Clinic No.	Age	Sex	Preoperative Visual Acuity and Refraction	Postoperative Visual Acuity and Refraction	Length of Follow-Up Period, Mo.	Clarity of Graft	Final Visual Acuity
1937	1	509103	30	M	3/200; no improvement with lenses	20/27 with — 12.00 sph. ⊃ — 6.50 cyl., axis 5	134	Clear	Improved *
	2	509103	30	M	5/200; no improvement with lenses	Count fingers; no improvement with lenses	10†	Cloudy	Unchanged‡
1938	3	543635	40	M	Count fingers; no improvement with lenses	6/200 with — 18.00 sph. ⊃ — 3.50 cyl., axis 110	50	Clear	Unchanged
	4	560902	11	M	Count fingers; no improvement with lenses	2/200 with — 19.00 sph. ⊃ — 3.00 cyl., axis 150	108	Clear	Unchanged
1939	5	543603	28	M	3/200; no improvement with lenses	20/50 with — 13.00 sph. ⊃ — 4.50 cyl., axis 180	6	Clear	Improved
	6	808397	24	M	3/200; 20/50 with contact lens	Count fingers; no improvement with lenses	74†	Clear	Loss of vision§
1940	7	560602	12	M	8/200 with lenses; refraction unknown	Hand movements; no improvements with lenses	6†	Opaque	Loss of vision
	8	604282	22	M	20/200; refraction unknown	20/50 with — 8.50 sph. ⊃ — 2.50 cyl., axis 90	67	Clear	Improved
1941	9	604282	22	M	20/70; refraction unknown	8/200 with — 6.50 sph.	63	Clear	Loss of vision
	10	808397	30	M	8/200; 20/50 with contact lens	Count fingers; no improvement with lenses	72	Clear	Loss of vision
1942	11	448027	31	M	Count fingers; no improvement with lenses	20/30 with — 7.50 sph. ⊃ — 3.00 cyl., axis 10	48	Clear	Improved
	12	693638	21	M	2/200; no improvement with lenses	Hand movements; no improvement with lenses	24	Opaque	Loss of vision
1943	13	644067	29	M	Count fingers; no improvement with lenses	Hand movements; no improvement with lenses	24†	Opaque	Unchanged
	14	448027	32	M	20/30 with lenses; refraction unknown	20/40 with — 13.00 sph. ⊃ — 3.00 cyl., axis 65	36	Clear	Unchanged
	15	604321	27	F	Count fingers; refraction unknown	Count fingers; no improvement with lenses	56	Opaque	Unchanged
1944	16	689040	40	F	3/200; no improvement with lenses	Hand movements; no improvement with lenses	25	Opaque	Loss of vision
	17	729178	20	M	5/200; no improvement with lenses	20/30 with + 4.50 sph. ⊃ + 3.00 cyl., axis 110	13	Clear	Improved
	18	745918	30	F	20/200; no improvement with lenses	20/50 with — 11.50 sph. ⊃ — 7.00 cyl., axis 25	48	Clear	Improved
	19	747056	41	F	20/100 with lenses; refraction unknown	2/200; no improvement with lenses	9	Cloudy	Loss of vision
	20	729178	21	M	**20/20 with correction of** + 3.75 D., axis 80 (20/40 without corr.)	20/70; no improvement with lenses	7	Clear	Loss of vision
1945	21	626314	28	M	8/200; no improvement with lenses	Hand movements; no improvement with lenses	13	Opaque	Loss of vision
	22	756609	43	F	Count fingers; no improvement with lenses	Count fingers; no improvement with lenses	11	Cloudy	Unchanged
	23	756488	42	F	2/200; no improvement with lenses	7/200 with — 2.00 sph. ⊃ — 7.00 cyl., axis 120	29	Clear	Unchanged
	24	805184	26	M	Count fingers; no improvement with lenses	20/30 with — 8.00 sph. ⊃ — 4.50 cyl., axis 105	27	Clear	Improved
1946	25	812239	33	F	Count fingers; no improvement with lenses	No light perception	22	Opaque	Loss of all vision
	26	813875	35	M	20/100 with contact lens (well tolerated)	Hand movements; no improvement with lenses	9†	Opaque	Loss of vision
	27	794725	44	F	Count fingers; no improvement with lenses	Count fingers; no improvement with lenses	29†	Clear	Unchanged
	28	817600	25	F	15/200; no improvement with lenses	20/50 with + 1.50 sph. ⊃ — 4.00 cyl., axis 25	9	Clear	Improved
	29	753416	31	F	Count fingers; no improvement with lenses	Hand movements; no improvement with lenses	16	Opaque	Unchanged
	30	745918	31	F	10/200; no improvement with lenses	20/100 with — 10.00 sph. ⊃ — 7.00 cyl., axis 120	24	Clear	Improved
	31	841715	21	M	Count fingers; no improvement with lenses	Count fingers; no improvement with lenses	8	Cloudy	Unchanged
	32	794725	45	F	Count fingers; no improvement with lenses	Hand movements; no improvement with lenses	24†	Cloudy	Unchanged
	33	805184	27	M	10/200; no improvement with lenses	Light perception; no improvement with lenses	15†	Opaque	Loss of vision
	34	847561	29	F	5/200; no improvement with lenses	Count fingers; no improvement with lenses	7	Opaque	Unchanged
1947	35	858475	19	F	10/200 with — 16.00 sph. ⊃ — 8.00 cyl., axis 180	20/100 with — 5.50 sph. ⊃ — 3.00 cyl., axis 155	14	Cloudy	Improved

* Final visual acuity was improved to better than 20/200.
† Followed by a second corneal transplantation.
‡ No significant change in visual acuity occurred.
§ Final visual acuity was decreased more than one step in the visual scale.

2 patients, improved visual acuity in one eye and no significant change in the other, and 3 patients, improved visual acuity in one eye and a loss of vision in the other eye. Of the 3 remaining patients, 1 had bilateral loss of vision, 1 had no significant change in either eye and 1 had a loss of vision in one eye with no significant change in the other. The secondary transplantations, therefore, resulted in improvement in vision in 2 instances.

Fig. 1.—Photograph, taken nine years after operation, of a clear corneal transplant (operation 4) without improvement in vision. Before operation vision was reduced by keratoconus to counting fingers; postoperative visual acuity was limited to perception of hand movements, correctable to 2/200 with a high minus lens.

Fig. 2.—Photograph, one year after operation, of a clear corneal transplant (operation 36) without significant improvement in vision. Before operation familial corneal dystrophy reduced this patient's vision to perception of hand movements. Postoperative visual acuity was corrected to 20/50 for nearly a year, when the cornea began to bulge forward, causing steadily increasing myopia and reduction in vision. Sixteen months after operation visual acuity was improved to 12/200 with a high minus lens only with difficulty.

Corneal Dystrophies.—Thirteen corneal transplantations were performed on 13 patients with corneal dystrophy. There were 3 eyes with Haab-Dimmer lattice dystrophy, 1 eye with Groenouw's nodular

dystrophy, 1 eye with Fuchs's epithelial dystrophy [23] and 8 eyes with unclassified dystrophies. The results are shown in table 3. Before operation visual acuity was less than 20/200 in all 13 eyes. After operation visual acuity was improved in 2 eyes, unchanged in 7 eyes and decreased in 4 eyes. There was loss of all light perception in 2 eyes. The 2 improved eyes each obtained visual acuity of 20/100, with moderately high myopic correction. Four eyes had clear grafts; 2, cloudy grafts, and 7, opaque grafts. Figure 2 is a photograph of one of the

TABLE 3.—*Results of Corneal Transplantation in Cases of Corneal Dystrophy*

Year	Operation No.	Clinic No.	Age	Sex	Preoperative Visual Acuity and Refraction	Postoperative Visual Acuity and Refraction	Length of Follow-Up Period, Mo.	Clarity of Graft	Final Visual Acuity
					Haab-Dimmer Type				
1947	36	858147	32	F	Hand movements; no improvement with lenses	12/200 with −9.00 sph. ⊂ −6.00 cyl., axis 105	16	Clear	Unchanged
	37	860466	35	F	2/200; no improvement with lenses	No light perception	15	Opaque	Loss of all vision
	38	864191	61	M	4/200; no improvement with lenses	20/100 with −5.50 sph. ⊂ −1.50 cyl., axis 100	14	Clear	Improved
					Groenouw's Type				
1946	39	833160	42	F	Hand movements; no improvement with lenses	20/100 with −4.00 sph. ⊂ −8.00 cyl., axis 160	8	Clear	Improved
					Fuch's Epithelial Type				
1938	40	561773	55	M	4/200; no improvement with lenses	Light perception; no improvement with lenses	12*	Opaque	Loss of vision
					Unclassified				
1945	41	772717	44	M	20/200 with lenses; refraction unknown	6/200 with −9.00 sph. ⊂ −1.50 cyl., axis 165	24	Clear	Unchanged
1946	42	803631	59	F	10/200; refraction unknown	5/200; no improvement with lenses	11	Opaque	Unchanged
	43	847506	68	F	Count fingers; no improvement with lenses	No light perception	20	Opaque	Loss of all vision
	44	843156	29	M	Count fingers; no improvement with lenses	Hand movements; no improvement with lenses	15	Cloudy	Unchanged
	45	847257	33	F	10/200; no improvement with lenses	Light perception; no improvement with lenses	14*	Opaque	Loss of vision
	46	826724	24	F	3/200; no improvement with lenses	15/200 with −10.00 sph.	11	Cloudy	Unchanged
	47	855524	20	M	3/200; no improvement with lenses	8/200 with −11.00 sph.	16	Opaque	Unchanged
	48	884815	30	F	Count fingers; no improvement with lenses	Hand movements; no improvement with lenses	10	Opaque	Unchanged

* Followed by a second corneal transplantation.

clear grafts (operation 36) without improvement in vision. The patient had 20/50 vision, with high myopic correction, for approximately one year after operation, when the graft began to bulge outward, as in conical cornea, with rapid loss of visual acuity. The follow-up period for this group averaged 14.3 months. Two patients in this group of dystrophies had secondary corneal transplantations, neither of which resulted in improvement.

23. Fuchs's epithelial dystrophy should not be considered with the other types of dystrophy in this category. The operation for this condition was included in this group because a single case did not appear to justify separate classification.

Interstitial Keratitis.—Twenty-one corneal transplantations were performed on 17 patients with interstitial keratitis. The results of these operations are shown in table 4. Preoperative visual acuity was better than 20/200 in 2 eyes and varied from light perception to 20/200 in the remaining 19 eyes. After operation, visual acuity was improved in 3 eyes and was unchanged in 11 eyes, and there was a decrease of vision in 7 eyes. Loss of all light perception occurred in 1 eye (operation 49). Two of the 3 eyes with postoperative visual acuity of better than 20/200 required modest correction for hypermetropia, while the third eye required a high myopic lens. The grafts remained clear in 5 eyes, became cloudy in 4 eyes and became opaque in 10 eyes. One eye was enucleated four days after transplantation because of panophthalmitis, and the graft became detached in 1 eye. Figure 3 is a photograph of a clear graft (operation 59) associated with a loss of

Fig. 3.—Photograph of a clear corneal transplant (operation 59) with loss of visual acuity. Before operation visual acuity was reduced to 20/100 by interstitial keratitis; postoperative visual acuity was reduced to counting fingers and was not improved with lenses.

vision. Before operation this patient had 20/100 visual acuity in this eye with correction; seven years after operation, although the graft remained perfectly clear, vision was limited to counting fingers and there was no improvement with lenses. The follow-up period for these 21 operations averaged 33.3 months. Eight patients in this group had secondary corneal transplantations, none of which was successful.

Chemical Burns.—Nine corneal trasplantations were performed on 7 patients with chemical burns of the cornea. Three of these patients suffered acid burns; 2, alkaline burns, and the remaining 2, chemical burns of uncertain nature. The results of these corneal transplantations are shown in table 5. Preoperative visual acuity was less than 20/200 in all 9 eyes: Vision in 4 eyes was limited to counting fingers, in 3 eyes to light perception and in 1 eye to perception of hand movements,

TABLE 4.—*Results of Corneal Transplantation in Cases of Interstitial Keratitis*

Year	Operation No.	Clinic No.	Age	Sex	Preoperative Visual Acuity and Refraction	Postoperative Visual Acuity and Refraction	Length of Follow-Up Period, Mo.	Clarity of Graft	Final Visual Acuity
1933	49	329859	69	M	6/200; no improvement with lenses	No light perception (enucleation 4 days postoperatively)	4	.....	Loss of all vision
1935	50	441489	39	M	20/200; no improvement with lenses	Light perception; no improvement with lenses	4*	.....	Loss of vision
	51	389963	25	M	Count fingers; no improvement with lenses	Count fingers; no improvement with lenses	7	Clear	Unchanged
1936	52	497487	19	F	Light perception; no improvement with lenses	Light perception; no improvement with lenses	120	Cloudy	Unchanged
	53	497487	19	F	Count fingers; no improvement with lenses	5/200; no improvement with lenses	22*	Cloudy	Unchanged
1937	55	489840	38	F	20/70 with −3.50 sph. ⌒ −1.50 cyl., axis 90	Count fingers; no improvement with lenses	4*	Cloudy	Loss of vision
	54	489840	38	F	20/200 with −3.50 sph.	20/70 with −12.00 sph.	6	Clear	Improved
1939	56	780639	22	F	3/200; no improvement with lenses	Hand movements; no improvement with lenses	98	Opaque	Loss of vision
	57	594229	32	M	20/200 with +1.00 sph. ⌒ +5.00 cyl., axis 180	Hand movements; no improvement with lenses	18*	Opaque	Loss of vision
1941	58	633231	24	M	Hand movements; no improvement with lenses	Count fingers; no improvement with lenses	90	Opaque	Unchanged
	59	610734	48	F	20/100 with −4.00 sph.	Count fingers; no improvement with lenses	80*	Opaque	Loss of vision
	60	633231	24	M	Hand movements; no improvement with lenses	Hand movements; no improvement with lenses	42*	Opaque	Unchanged
1942	61	646646	40	F	2/200; no improvement with lenses	Count fingers; no improvement with lenses	20	Opaque	Unchanged
1944	62	766136	27	M	Count fingers; no improvement with lenses	20/30 with +2.00 cyl., axis, 135	32	Clear	Improved
	63	766136	27	M	10/200; no improvement with lenses	20/50 with +2.00 sph. ⌒ +2.25 cyl., axis 45	31	Clear	Improved
1945	64	756698	56	M	Count fingers; no improvement with lenses	3/200 with +10.00 sph. ⌒ +6.00 cyl., axis 85	42	Opaque	Unchanged
	65	782144	29	M	5/200 with −20.00 sph.	Count fingers; no improvement with lenses	14*	Opaque	Unchanged
1946	66	654802	15	F	Count fingers; no improvement with lenses	Light perception; no improvement with lenses	22*	Opaque	Loss of vision
	67	834570	26	F	10/200; no improvement with lenses	Count fingers; no improvement with lenses	18	Cloudy	Unchanged
	68	833467	28	F	Hand movements; no improvement with lenses	Hand movements; no improvement with lenses	6	Opaque	Unchanged
1947	69	865196	21	F	20/200; refraction unknown	10/200; no improvement with lenses	15	Clear	Unchanged

* Followed by a second corneal transplantation.

TABLE 5.—*Results of Corneal Transplantation in Cases of Chemical Burns*

Year	Operation No.	Clinic No.	Age	Sex	Preoperative Visual Acuity and Refraction	Postoperative Visual Acuity and Refraction	Length of Follow-Up Period, Mo.	Clarity of Graft	Final Visual Acuity
1933	70	365896	40	M	5/200; no improvement with lenses	Count fingers; no improvement with lenses	14*	Opaque	Unchanged
1934	71	460643	22	M	Hand movements; no improvement with lenses	Hand movements; no improvement with lenses	26*	Cloudy	Unchanged
1935	72	442672	26	M	Light perception; no improvement with lenses	No light perception	8	Opaque	Loss of all vision
	73	457018	22	M	Light perception; no improvement with lenses	Light perception; no improvement with lenses	43*	Opaque	Unchanged
	74	458682	23	M	Count fingers; no improvement with lenses	Count fingers; no improvement with lenses	47*	Opaque	Unchanged
	75	458682	23	M	Count fingers; no improvement with lenses	Count fingers; no improvement with lenses	8*	Opaque	Unchanged
	76	441982	36	M	Light perception; no improvement with lenses	Light perception; no improvement with lenses	1	.....	Unchanged
1938	77	875514	31	M	Count fingers; no improvement with lenses	Light perception; no improvement with lenses	120	Opaque	Loss of vision
	78	875514	31	M	Count fingers; no improvement with lenses	Count fingers; no improvement with lenses	8*	Opaque	Unchanged

* Period followed by second corneal transplantation.

TABLE 6.—*Results of Corneal Transplantation in Cases of Traumatic Scars*

Year	Operation No.	Clinic No.	Age	Sex	Preoperative Visual Acuity and Refraction	Postoperative Visual Acuity and Refraction	Length of Follow-Up Period, Mo.	Clarity of Graft	Final Visual Acuity
1934	79	346698	22	F	Light perception; no improvement with lenses	Hand movements; no improvement with lenses	144	Opaque	Unchanged
1935	80	454243	55	F	8/200; no improvement with lenses	Hand movements; no improvement with lenses	10	Opaque	Loss of vision
1937	81	514299	29	M	6/200; no improvement with lenses	10/200 with + 9.00 sph.	61	Clear	Unchanged
1944	82	752341	26	M	5/200; no improvement with lenses	Count fingers; no improvement with lenses	46	Opaque	Unchanged
1945	83	608599	41	M	20/200; no improvement with lenses	20/70 with — 0.50 sph. ⊃ — 4.00 cyl., axis 130	39	Clear	Improved
	84	789971	36	M	20/40 with + 3.50 sph.	20/200 (improved to 20/20 with a very high correction, but patient could not wear it)	13	Clear	Loss of vision

TABLE 7.—*Results of Corneal Transplantation in Cases with Postinflammatory Scars*

Year	Operation No.	Clinic No.	Age	Sex	Preoperative Visual Acuity and Refraction	Postoperative Visual Acuity and Refraction	Length of Follow-Up Period, Mo.	Clarity of Graft	Final Visual Acuity
1933	85	324378	55	F	Hand movements; no improvement with lenses	Light perception; no improvement with lenses	25	Opaque	Unchanged
	86	411857	20	M	Count fingers; no improvement with lenses	Count fingers; no improvement with lenses	15*	Cloudy	Unchanged
1935	87	455825	16	M	Hand movements; no improvement with lenses	Hand movements; no improvement with lenses	27	Opaque	Unchanged
1936	88	371425	24	M	Hand movements; no improvement with lenses	Hand movements; no improvement with lenses	27*	Cloudy	Unchanged
	89	487454	35	M	20/200; no improvement with lenses	Hand movements; no improvement with lenses	12*	Opaque	Loss of vision
1937	90	522939	45	M	Hand movements; no improvement with lenses	Light perception; no improvement with lenses	27	Opaque	Unchanged
	91	847335	26	F	Hand movements; no improvement with lenses	Hand movements; no improvement with lenses	12*	Cloudy	Unchanged
1938	92	406036	30	M	10/200; no improvement with lenses	20/200 with — 1.00 sph. ⊃ + 9.00 cyl., axis 70	102	Clear	Unchanged
	93	558409	13	F	10/200; no improvement with lenses	20/70 with — 3.50 sph.	80	Clear	Improved
	94	561434	29	F	Hand movements; no improvement with lenses	No light perception	115	Opaque	Loss of all vision
1939	95	580881	24	F	Light perception; no improvement with lenses	No light perception	36	Opaque	Loss of all vision
1940	96	565344	5	M	Light perception; no improvement with lenses	Light perception; no improvement with lenses	10*	Opaque	Unchanged
	97	568702	6	M	Hand movements; no improvement with lenses	12/200; no improvement with lenses	96	Clear	Unchanged
	98	332408	13	F	10/200; no improvement with lenses	No light perception (enucleation)	2	Opaque	Loss of all vision
	99	617664	18	F	20/200; no improvement with lenses	Hand movements; no improvement with lenses	36	Clear	Loss of vision
1941	100	624147	23	M	20/50 with — 0.50 sph.	Hand movements; no improvement with lenses	38*	Opaque	Loss of vision
	101	533789	47	M	Hand movements; no improvement with lenses	No light perception	13	Opaque	Loss of all vision
1944	102	600653	55	F	Count fingers; no improvement with lenses	Count fingers; no improvement with lenses	11	Cloudy	Unchanged
1945	103	770061	37	F	Hand movements; no improvement with lenses	3/200; no improvement with lenses	13	Cloudy	Unchanged
1947	104	824446	35	F	Hand movements; no improvement with lenses	Hand movements; no improvement with lenses	18	Opaque	Unchanged
	105	827386	27	F	20/70; no improvement with lenses	20/200; no improvement with lenses	9	Cloudy	Loss of vision
	106	878080	22	M	5/200; no improvement with lenses	20/40 with — 0.50 sph. ⊃ + 2.50 cyl., axis 75	9	Clear	Improved

* Followed by second corneal transplantation.

and in 1 eye visual acuity was 5/200. In none of these eyes was postoperative visual acuity improved to better than 20/200. In 7 eyes there was no significant change in vision, and 2 eyes showed a loss of vision. There were no transparent grafts in this series. One graft became cloudy, and 7 grafts became opaque; 1 transplant was detached and lost. The average follow-up period for the group was 30.5 months. Five of these patients with chemical burns had multiple operations; 2 had corneal transplantations on both eyes, and all 5 had secondary corneal transplantations. Two patients had 4 grafts (2 on each eye), and 1 patient (operation 71) had 4 grafts on one eye. None of the 9 secondary transplantations resulted in improvement of vision. Three of the latter operations resulted in loss of light perception.

Traumatic Scars.—Six corneal transplantations were performed on 6 patients with corneal scars resulting from trauma. The results in these cases are shown in table 6. Preoperative visual acuity was 20/200 or less in 5 eyes and 20/40, with correction, in 1 eye. Postoperative visual acuity was improved in 1 eye; there was no significant change in visual acuity in 3 eyes, and there was loss of vision in 2 eyes. There were clear transplants in 3 eyes and opaque transplants in 3 eyes. The follow-up period for the group averaged 52.1 months. There were no secondary transplantations in these cases.

Postinflammatory Scars.—Twenty-two corneal transplants were performed on 22 patients with corneal lesions following a definite inflammatory process. The inflammations given in the histories of these patients were as follows:

	No. of Cases
Corneal ulcer	4
Diphtheria	2
Trachoma	1
Ophthalmia neonatorum	1
Gonorrheal infection in the adult	1
Corneal abscess	1
Measles	1
Inflammation of uncertain cause	11
Total	22

The pertinent data in this series of operations are shown in table 7. Preoperative visual acuity was better than 20/200 in 2 eyes and varied from light perception to 20/200 in the remaining 20 eyes. Postoperative visual acuity was improved in 2 eyes, to 20/40 in 1 case and to 20/70 in the other; both eyes required myopic correction to attain this acuity. There was no significant change in vision in 12 eyes, and a loss of vision occurred in 8 eyes, with loss of light perception in 4 of these 8 eyes. There were clear transplants in 5 eyes, cloudy transplants

in 6 eyes and opaque transplants in 11 eyes. Figure 4 is a photograph of the clear graft (operation 99) associated with a decrease in vision. Visual acuity in this eye was 20/200 before operation and was limited to perception of hand movements after transplantation. The follow-up period for the group averaged 33.3 months. Six patients had secondary corneal transplantations, none of which resulted in improved vision.

Fig. 4.—Photograph of a clear corneal transplant (operation 99) associated with loss of vision. Before operation a corneal leukoma reduced visual acuity to 20/200; after operation visual acuity was reduced to perception of hand movements and was not improved with lenses.

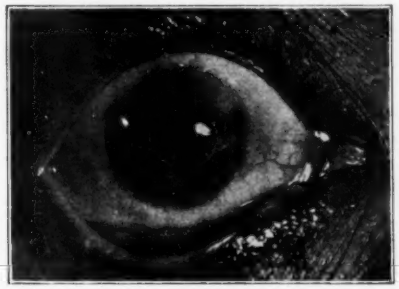

Fig. 5.—Photograph, taken fourteen months after operation, of a clear corneal transplant (operation 118) with improved vision. Before operation corneal leukomas of unknown origin reduced this patient's vision to perception of hand movements in each eye. After a transplant on each eye, visual acuity with correction was 20/50 in each eye.

7. Corneal Scars of Unknown Origin.—Twenty-four corneal transplantations were performed on 19 patients with corneal scars but without a definite history of ocular disease or injury. It is likely that many of these scars belonged in the preceding (postinflammatory) group. Also included in this category are the following miscellaneous conditions: primary fatty degeneration of the cornea, 1 case; band keratitis,

1 case; a descemetocele, 1 case, and Hurler's syndrome (lipochondrodystrophy), 1 case. The results in this group of assorted cases are shown in table 8. Preoperative visual acuity was 20/40 and 20/70 in

TABLE 8.—*Results of Corneal Transplantation Cases with Scars of Unknown Cause*

Year	Operation No.	Clinic No.	Age	Sex	Preoperative Visual Acuity and Refraction	Postoperative Visual Acuity and Refraction	Length of Follow-Up Period, Mo.	Clarity of Graft	Final Visual Acuity
1934	107	750738	58	F	Hand movements; no improvement with lenses	Count fingers; no improvement with lenses	168	Opaque	Unchanged
	106	750738	58	F	4/200; no improvement with lenses	5/200; no improvement with lenses	44*	Opaque	Unchanged
1935	109	489832	21	M	Count fingers; no improvement with lenses	Count fingers; no improvement with lenses	14*	Opaque	Unchanged
1936	110	488464	60	M	3/200; no improvement with lenses	Count fingers; no improvement with lenses	72	Cloudy	Unchanged
	111	470086	24	M	Light perception; no improvement with lenses	No light perception	49	Opaque	Loss of all vision
	112	488464	60	M	20/70: no improvement with lenses	10/200; no improvement with lenses	72	Cloudy	Loss of vision
1937	113	509661	41	F	Hand movements; no improvement with lenses	Hand movements; no improvement with lenses	34*	Opaque	Unchanged
	114	509661	41	F	Count fingers; no improvement with lenses	Count fingers; no improvement with lenses	33*	Opaque	Unchanged
	115	516335	48	F	Hand movements; no improvement with lenses	20/50 with + 4.00 sph. ⊃ + 1.00 cyl., axis 120	48	Clear	Improved
	116	524083	44	F	5/200; no improvements with lenses	10/200; no improvement with lenses	19	Cloudy	Unchanged
	117	459169	41	F	Count fingers; no improvement with lenses	Light perception; no improvement with lenses	95	Opaque	Loss of vision
	118	516335	48	F	Hand movements; no improvement with lenses	20/50 with + 1.00 sph.	45	Clear	Improved
	119	519674	20	M	10/200; no improvement with lenses	Hand movements; no improvement with lenses	42	Cloudy	Loss of vision
1938	120	542880	11	M	Hand movements; no improvement with lenses	Hand movements; no improvement with lenses	110	Opaque	Unchanged
1939	121	573564	44	M	15/200; no improvement with lenses	Light perception; no improvement with lenses	5*	Cloudy	Loss of vision
1941	122	643388	45	M	5/200; no improvement with lenses	No light perception	82	Opaque	Loss of all vision
1942	123	627786	28	F	15/200; no improvement with lenses	20/200; no improvement with lenses	72	Cloudy	Unchanged
1944	124	764672	35	F	6/200; no improvement with lenses	10/200; no improvement with lenses	15*	Cloudy	Unchanged
1945	125	764287	56	F	Count fingers; no improvement with lenses	Light perception; no improvement with lenses	10	Cloudy	Loss of vision
					Primary Fatty Degeneration of Cornea				
1939	126	557042	39	M	20/200; no improvement with lenses	Count fingers; no improvement with lenses	108	Opaque	Loss of vision
	127	557042	39	M	20/200; no improvement with lenses	Count fingers; no improvement with lenses	41*	Opaque	Loss of vision
					Band Keratitis				
1945	128	752428	52	F	3/200 with — 3.25 sph.	5/200 with — 10.00 sph.	40	Clear	Unchanged
					Descemetocele				
	129	867895	32	F	20/40; no refraction	3/200; no improvement with lenses	25	Clear	Loss of vision
					Hurler's Syndrome				
1948	130	898612	18	M	2/200; no improvement with lenses	No light perception (enucleation)	1	.....	Loss of all vision

* Followed by another corneal transplantation.

2 eyes and ranged from 20/200 to light perception in the remaining 22 eyes. After operation, visual acuity was improved in 2 eyes, unchanged in 11 eyes and decreased in 11 eyes. Three eyes in the last group showed complete loss of vision. The 2 successful opera-

tions (115 and 118) were performed on the same patient. In this patient, preoperative vision was equal to perception of hand movements in each eye, not improved with lenses; postoperative visual acuity was 20/50 in each eye, with hypermetropic correction. Figure 5 is a photograph of the patient's right eye after operation. There were 4 clear grafts, 8 cloudy grafts and 11 opaque grafts in this series of operations; 1 graft became detached, and the eye was enucleated. The follow-up period for these patients averaged 51.8 months. Eight patients

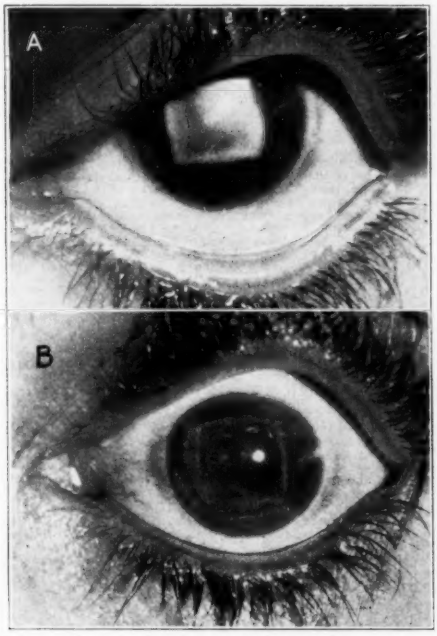

Fig. 6.—Photographs showing a clear secondary corneal transplant. *A*, photograph, six months after operation, of the result of the initial operation on that eye (operation 7); vision was then limited to perception of hand movements and was not improved with lenses. *B*, photograph, seven months after operation, showing result of the second transplantation; visual acuity was then improved to 20/50 with a very high minus lens.

had multiple corneal transplantations. Five patients had a corneal transplantation on each eye, and 6 patients had 7 secondary corneal transplantations, none of which was successful.

8. *Secondary Corneal Transplantations.*—Thirty-five corneal transplantations were performed on 32 eyes on which one or more corneal transplantations had already been done. (There were 5 additional sec-

TABLE 9.—*Results in Secondary Corneal Transplantation*

Year	Operation No.	Clinic No.	Age	Sex	Preoperative Visual Acuity and Refraction	Postoperative Visual Acuity and Refraction	Length of Follow-Up Period, Mo.	Clarity of Graft	Final Visual Acuity
1934	131	365895	41	M	Count fingers; no improvement with lenses	No light perception	39	Opaque	Loss of all vision
1935	132	441849	39	M	Hand movements; no improvement with lenses	Hand movements; no improvement with lenses	60	Opaque	Unchanged
	133	411857	21	M	Count fingers; no improvement with lenses	Hand movements; no improvement with lenses	51	Cloudy	Unchanged
1936	134	458682	24	M	Count fingers; no improvement with lenses	Hand movements; no improvement with lenses	88	Opaque	Unchanged
	135	439832	21	M	Count fingers; no improvement with lenses	No light perception	7	Opaque	Loss of all vision
	136	466643	22	M	Hand movements; no improvement with lenses	Hand movements; no improvement with lenses	8*	Cloudy	Unchanged
1937	137	466643	23	M	Hand movements; no improvement with lenses	Hand movements; no improvement with lenses (third transplant)	9*	Cloudy	Unchanged
	138	759738	58	F	5/200; no improvement with lenses	Hand movements; no improvement with lenses	135	Opaque	Loss of vision
	139	487454	37	M	Hand movements; no improvement with lenses	No light perception	17	Opaque	Loss of all vision
	140	466643	23	M	Hand movements; no improvement with lenses	No light perception (enucleation; 4th transplant)	43	Opaque	Loss of all vision
1938	141	509103	30	M	Count fingers; no improvement with lenses	Light perception; no improvement with lenses	117	Cloudy	Loss of vision
	142	371425	28	M	Hand movements; no improvement with lenses	Light perception; no improvement with lenses	30	Clear	Unchanged
	143	497487	20	F	5/200; no improvement with lenses	8/200; no improvement with lenses	99	Cloudy	Unchanged
	144	847335	27	F	Hand movements; no improvement with lenses	No light perception	96	Opaque	Loss of all vision
	145	875514	31	M	Hand movements; no improvement with lenses	Hand movements; no improvement with lenses	6*	Opaque	Unchanged
1939	146	457018	25	M	Light perception; no improvement with lenses	Light perception; no improvement with lenses	111	Opaque	Unchanged
	147	458682	27	M	Count fingers; no improvement with lenses	Hand movements; no improvement with lenses	50	Opaque	Unchanged
	148	875514	31	M	Hand movements; no improvement with lenses	No light perception (3d transplant)	105	Opaque	Loss of all vision
	149	489840	38	F	Count fingers; no improvement with lenses	20/200; no improvement with lenses	15	Clear	Unchanged
	150	561773	56	M	Light perception; no improvement with lenses	Hand movements; no improvement with lenses	70	Cloudy	Unchanged
	151	573564	44	M	Count fingers; no improvement with lenses	Light perception; no improvement with lenses	34	Opaque	Loss of vision
1940	152	560092	13	M	Hand movements; no improvement with lenses	20/50 with −20.00 sph. ⊂ −3.00 cyl., axis 40	49	Clear	Improved
	153	565344	6	M	Light perception; no improvement with lenses	Hand movements; no improvement with lenses	68	Clear	Unchanged
1941	154	504290	33	M	Hand movements; no improvement with lenses	Count fingers; no improvement with lenses	79	Cloudy	Unchanged
1943	155	557042	42	M	Count fingers; no improvement with lenses	Count fingers; no improvement with lenses	63	Opaque	Unchanged
1944	156	624147	28	M	Hand movements; no improvement with lenses	Hand movements; no improvement with lenses	7	Opaque	Unchanged
	157	633231	27	M	Hand movements; no improvement with lenses	Hand movements; no improvement with lenses	44	Opaque	Unchanged
1945	158	644067	31	M	Hand movements; no improvement with lenses	Count fingers; no improvement with lenses	44	Opaque	Unchanged
	159	808397	35	M	Count fingers; no improvement with lenses	20/70 with −4.00 sph. ⊂ −1.25 cyl., axis 50	20	Clear	Improved
1946	160	764072	36	F	10/200; no improvement with lenses	4/200; no improvement with lenses	28	Cloudy	Unchanged
	161	813875	36	M	Hand movements; no improvement with lenses	No light perception	11	Opaque	Loss of all vision
	162	782144	30	M	Count fingers; no improvement with lenses	No light perception (enucleation)	4	Opaque	Loss of all vision
1947	163	610734	52	F	Count fingers; no improvement with lenses	Count fingers; no improvement with lenses	9	Cloudy	Unchanged
	164	654802	17	F	Light perception; no improvement with lenses	7/200; no improvement with lenses	7	Opaque	Unchanged
	165	805184	28	M	Light perception; no improvement with lenses	Light perception; no improvement with lenses	6	Opaque	Unchanged

* Followed by a third corneal transplantation.

ondary operations among the cases excluded for lack of a six months' follow-up.) The initial lesions in these 32 eyes before the first corneal transplantation were as follows:

	No. of Eyes
Keratoconus	6
Corneal dystrophy	1
Interstitial keratitis	8
Chemical burns	6
Postinflammatory scars	6
Scars of unknown etiology	5
Total	32

After the first corneal transplantation, the pathologic process in these eyes had little in common with these lesions. After operation the corneas, for the most part, showed extensive vascularization and opacification, and the majority of the eyes had secondary glaucoma. Therefore, because they resembled each other more than anything else, these eyes have been grouped together in this separate division. The data on these secondary operations are shown in table 9. Preoperative vision in these eyes ranged from light perception to 10/200. After operation, 2 eyes showed improved visual acuity, 1 to 20/50 and 1 to 20/70, both eyes requiring myopic lenses. Twenty-two eyes showed no significant change in vision, and 11 eyes showed a loss of vision. Loss of light perception occurred in 8 of the last eyes. Figure 6 shows photographs of 1 of the eyes with a successful result, (*a*) before the second operation, showing the result of operation 7, and (*b*) seven months after the second transplantation (operation 152). Clear grafts resulted in 5 eyes, cloudy grafts in 9 eyes and 21 opaque grafts in 21 eyes in this series. The average follow-up period for the group was 46.5 months.

COMMENT

The visual and cosmetic results in 165 corneal transplantations have been reviewed in groups arranged according to the diagnosis. Seventeen other transplants were excluded because the results had not been followed for six months after operation. Except for these 17 operations, there has been no exclusion or selection of cases. Many of the unsuccessful results in this series might well be attributed to various preoperative and postoperative complications, but a discussion of this large subject (factors affecting the outcome of the operation) has been deliberately avoided. The sole aim of this survey has been an objective evaluation of the results in an unselected series of corneal transplantations. A discussion of the results in the series as a whole now follows.

Vision.—The visual acuities, before and after operation, of the entire series are shown in table 10. The figures between the two heavy lines

running steplike across table 10 represent operations that resulted in no significant change in vision. The figures above the upper heavy line represent operations that resulted in improved visual acuity (better than 20/200). The figures below the lower heavy line represent operations that resulted in a loss of vision. The column of totals on the right side of the table refers to postoperative visual acuity and the row of totals across the bottom refers to preoperative visual acuity.

Preoperative visual acuity was better than 20/200 in 14 eyes, ranged between 20/200 and perception of hand movements in 138 eyes, and was limited to light perception in 13 eyes. Postoperative visual acuity was improved to better than 20/200 in 22 eyes, or 13.3 per cent of the series. There was no significant change in visual acuity in 86 eyes, or 52.1 per cent of the series. A loss of visual acuity followed 57 opera-

TABLE 10.—*Preoperative and Postoperative Visual Acuity in 165 Corneal Transplantations**

	Preoperative Visual Acuity											
Visual Acuity	20/20	20/30	20/40	20/50	20/70	20/100	11-20/200	1-10/200	Count Fingers	Hand Movements	Light Perception	Total No. of Operations
Postoperative visual acuity												
20/20	..	..	..	..	..	..	..	..	..	..	..	..
20/30	..	..	..	..	..	..	..	1	3	..	..	4
20/40	..	1	..	..	..	..	..	1	..	..	..	2
20/50	..	..	..	..	..	..	3	2	..	3	..	8
20/70	1	..	..	..	..	..	2	2	1	..	..	6
20/100	..	..	..	..	..	..	..	3	..	1	..	4
11-20/200	..	..	1	..	1	..	1	3	1	2	..	9
1-10/200	..	..	1	..	2	1	2	9	4	1	1	21
Count fingers	..	..	..	2	1	1	2	8	14	4	..	32
Hand movements	..	..	..	1	..	1	3	8	8	15	3	39
Light perception	..	..	..	..	..	..	2	3	6	3	6	20
No light perception	..	..	..	..	..	..	..	5	5	7	3	20
Total	1	1	2	3	4	3	15	45	42	36	13	165

* Values above the upper heavy line represent operations which resulted in improvement of vision; figures between the heavy lines, operations which resulted in no change of visual acuity, and values below the lower heavy line, operations which resulted in a loss of visual acuity.

tions, or 34.6 per cent of the series; in 20 of these eyes, or 12.1 per cent of the series, there was loss of light perception. None of the 14 eyes with better than 20/200 preoperative visual acuity obtained any further improvement. In 2 of these eyes visual acuity remained better than 20/200 after operation but was not improved.

A comparison of the visual results in the various diagnostic groups is shown in table 11. Several significant facts are illustrated by this tabulation: Almost half the successful results were obtained in the keratoconus group. In none of the eyes with chemical burns was a successful result attained. Only 2 eyes in the group of 35 eyes with secondary transplantation showed improved vision. Regardless of diagnosis, approximately one third of the operations resulted in decreased

visual acuity. According to the results in this series of operations, successful corneal transplants may be expected in (1) about 30 per cent of eyes with keratoconus; (2) in about 15 per cent of eyes with corneal dystrophy, interstitial keratitis or scarring from trauma; (3) in about 10 per cent of eyes with postinflammatory lesions or scars of unknown origin, and (4) in about 5 per cent of eyes that have already had a previous corneal transplantation.

Refraction.—The refractive errors in the 22 eyes with successful visual results are worthy of note. Visual acuity was improved, with correction, to 20/30 in 4 eyes, to 20/40 in 1 eye, to 20/50 in 8 eyes, to 20/70 in 5 eyes and to 20/100 in 4 eyes. To obtain this improvement, 15 eyes required minus lenses and 5 eyes plus lenses, and two

TABLE 11.—*Visual Results of Corneal Transplantation by Diagnostic Groups*

Diagnosis	Number of Operations	Visual Acuity		
		Improved	Unchanged	Decreased
Keratoconus	35	10	13	12
Corneal dystrophies	13	2	7	4
Interstitial keratitis	21	3	11	7
Chemical burns	9	..	7	2
Traumatic scars	6	1	3	2
Postinflammatory scars	22	2	12	8
Scars of unknown cause	24	2	11	11
Secondary corneal grafts	35	2	22	11
Totals	165	22	86	57

eyes showed a mixed astigmatism. The correction in these lenses varied as follows:

	No. of Eyes
Minus sphere with minus cylinder	13
Average sphere, 8.4 D	
Average cylinder, 4.3 D	
Minus sphere (3.5 and 12.0 D.)	2
Plus sphere with plus cylinder	3
Average sphere, 3.5 D.	
Average cylinder, 3.0 D.	
Plus sphere (1.0 D.)	1
Plus cylinder (2.0 D.)	1
Mixed cylinder	2
Total	22

In addition to the successful results in these 22 eyes, small postoperative increases in visual acuity were obtained in 9 other eyes by means of high minus lenses. Without correction, vision in these eyes varied from perception of hand movements to 5/200, and with correction, from 2/200 to 15/200. The strength of the minus sphere for

these 9 eyes averaged 10.8 D., and the minus cylinders required for the 5 eyes averaged 4.5 D. These facts indicate that the refraction in postoperative corneal transplantation shows a definite trend toward high myopia. Presumably, this is evidence of a tendency in the grafted cornea to bulge.

Clarity of the Graft.—There was a marked difference between the number of successful visual results and the number of clear transplants in this series. The cosmetic results were as follows:

	Number	Percentage
Clear transplants	44	26.7
Cloudy transplants	36	21.8
Opaque transplants	81	49.1
Detachment of graft	3	1.8
Other (operation 49)	1	0.6
Total	165	

If one were to accept a transparent graft as evidence of a successful operation, as firmly advocated by Thomas,[24] the first two groups of transplantations would be successful. Judged by that standard, 80 operations, or 45.5 per cent of the series, were successful. From a functional point of view, however, this is hardly the case. Of the 44 eyes with clear grafts, visual acuity was improved in 21 eyes, unchanged in 16 eyes and decreased in 7 eyes. Of the 36 eyes with cloudy grafts, visual acuity was improved in 1 eye, unchanged in 27 eyes and decreased in 8 eyes. These results appear to demonstrate rather conclusively that there is no close correlation between transparency of the graft and improvement in vision.

Follow-up Period.—The average follow-up for this series of operations was 37.7 months. Patients followed for less than six months were excluded, except those in whom the final result became definite at an earlier date, i. e., detachment of the graft, enucleation or a second corneal transplantation. Omission of these operations would obviously subtract important information from a report. The number of such transplantations, for which the follow-up period was necessarily terminated and the final result known, was considerable (55 operations). Although longer than six months in most instances, the follow-up period was still comparatively short in this group and tended to lower the average for the entire series. When these 55 operations are excluded, the average follow-up period for the remainder of the series becomes 45.7 months. The latter figure, then, is the average follow-up interval for those transplants still under (or potentially under) observation and is more significant in the evaluation of results than the over-all average of 37.7 months.

24. Thomas[8] stated that transparency of the graft or amelioration of the corneal opacity constitutes the criterion for a successful operation.

Multiple Corneal Transplantations.—Thus far, the results in this series of corneal transplantations have been discussed only in relation to operations; the visual acuities here tabulated refer to vision in an eye before and after a particular operation, and are not necessarily the initial and/or the final findings for that eye. Approximately one fourth of the eyes undergoing operation in this series later had a second corneal transplantation, and the visual result of the second operation supersedes the result of the initial transplantation. Likewise, the results given up to this point are not applicable on a patient basis, because of the number of secondary operations and because of the number of patients having corneal grafts on both eyes. Clinically, one is more interested in the final result in each eye operated on and in each patient than in the rather abstract results per operation.

In order to analyze the results in this series of operations on the basis of eyes operated on and of patients, the data were rearranaged so that all operations on the same eye and/or the same patient were grouped together. The visual results in all patients who had more than one corneal transplantation are shown in table 12. The number of operations falling into this classification was large; of the 165 operations in this series, 96 were performed on 61 eyes of 41 patients who had more than one corneal graft. Part A of table 12 contains the results for 20 patients who had bilateral corneal transplantation, and part B contains the results for 21 patients who had more than one transplantation on one eye. In addition, 13 of the patients in part A had secondary transplantations on one or both eyes. In this multiple operation category, then, 41 patients had 61 initial corneal transplantations and 40 secondary transplantations, making a total of 101 operations for the group. Five of these secondary transplantations were among the 17 operations excluded from evaluation in this series because of a too brief follow-up period. The results in these 5 eyes are not given here except as being unknown, and they are included only because they are necessary to explain the outcome of the initial grafts in these same eyes, which do form part of the series. In the last column in table 12 the final visual acuity for the 61 eyes in the multiple operation group is given; this result is based on comparison of the final visual acuity with the visual acuity before the first corneal transplantation.

Results According to Eyes with Corneal Grafts: The 165 corneal transplantations of this series were performed on 130 eyes of 110 patients, 61 eyes belonging to the 41 patients having multiple operations and the remaining 69 eyes to patients having a single transplantation. The visual results in the 61 eyes of the first group are shown in table 12: improved visual acuity, 13 eyes; no significant change in visual acuity, 17 eyes; decreased visual acuity, 26 eyes, and unknown result, 5 eyes. The visual results in the 69 eyes of patients who had only a single corneal transplantation were not quite so good: improved visual acuity,

TABLE 12.—*Visual Results in Cases of Multiple Corneal Transplantations*

Case No.	Clinic No.	Eye	Initial Transplant: Operation No.	Initial Transplant: Visual Acuity	Secondary Transplant: Operation No.	Secondary Transplant: Visual Acuity	Totals: Eye	Totals: Patient	Final Visual Acuity *
A. Bilateral Transplants									
1	509103	OD	1	Improved	...	.....	1	..	Improved
		OS	2	Unchanged	141	Decreased	2	3	Decreased
2	560002	OD	4	Unchanged	...	.....	1	..	Unchanged
		OS	7	Decreased	152	Improved	2	3	Improved
3	806397	OD	10	Decreased	...	.....	1	..	Decreased
		OS	6	Decreased	159	Improved	2	3	Decreased
4	604282	OD	8	Improved	...	.....	1	..	Improved
		OS	9	Decreased	...	.....	1	2	Decreased
5	448027	OD	14	Unchanged	...	.....	1	..	Unchanged
		OS	11	Improved	...	.....	1	2	Improved
6	729178	OD	17	Improved	...	.....	1	..	Improved
		OS	20	Decreased	...	.....	1	2	Decreased
7	745918	OD	18	Improved	...	.....	1	..	Improved
		OS	30	Improved	...	.....	1	2	Improved
8	806174	OD	33	Decreased	165	Unchanged	2	..	Decreased
		OS	24	Improved	...	.....	1	3	Improved
9	794725	OD	27	Unchanged	Yes, but no follow-up		2	..	(Unknown)
		OS	32	Unchanged	Yes, but no follow-up		2	4	(Unknown)
10	497487	OD	53	Unchanged	143	Unchanged	2	..	Unchanged
		OS	52	Unchanged	...	.....	1	3	Unchanged
11	489840	OD	54	Improved	...	.....	1	..	Improved
		OS	55	Decreased	149	Unchanged	2	3	Decreased
12	633231	OD	58	Unchanged	...	.....	1	..	Unchanged
		OS	60	Unchanged	157	Unchanged	2	3	Unchanged
13	766136	OD	62	Improved	...	.....	1	..	Improved
		OS	63	Improved	...	.....	1	2	Improved
14	458682	OD	74	Unchanged	147	Unchanged	2	..	Unchanged
		OS	75	Unchanged	134	Unchanged	2	4	Unchanged
15	875514	OD	77	Decreased	...	.....	1	..	Decreased
		OS	78	Unchanged	145	Unchanged	..	..	
					148	No light perception	3	4	No light perception
16	759738	OD	107	Unchanged	...	.....	1	..	Unchanged
		OS	108	Unchanged	138	Decreased	2	3	Decreased
17	488464	OD	112	Decreased	...	.....	1	..	Decreased
		OS	110	Unchanged	...	.....	1	2	Unchanged
18	509661	OD	113	Unchanged	Yes, but no follow-up		2	..	(Unknown)
		OS	114	Unchanged	Yes, but no follow-up		2	4	(Unknown)
19	516335	OD	118	Improved	...	.....	1	..	Improved
		OS	115	Improved	...	.....	1	2	Improved
20	557042	OD	127	Decreased	135	Unchanged	2	..	Decreased
		OS	126	Decreased	...	.....	1	3	Decreased
Totals: 20 patients		40	Improved.....12 eyes Unchanged.....17 eyes Decreased.....11 eyes Total.....40 eyes		Improved..... 2 Unchanged..... 8 Decreased..... 3 Unknown..... 4 Total.....17		57 grafts		Improved....13 Unchanged 10 Decreased....13 Unknown.... 4 Total.....40
B. Unilateral Transplants									
1	644667	OS	13	Unchanged	158	Unchanged	2	..	Unchanged
2	813875	OD	26	Decreased	161	No light perception	2	..	No light perception
3	561773	OS	40	Decreased	150	Unchanged	2	..	Decreased
4	847257	OD	45	Decreased	Yes, but no follow-up		2	..	(Unknown)
5	441849	OS	50	Decreased	132	Unchanged	2	..	Decreased
6	594229	OD	57	Decreased	154	Unchanged	2	..	Decreased
7	610734	OS	59	Decreased	163	Unchanged	2	..	Decreased
8	782144	OD	65	Unchanged	162	No light perception	2	..	No light perception
9	654802	OD	66	Decreased	164	Unchanged	2	..	Unchanged
10	365895	OS	70	Unchanged	131	No light perception	2	..	No light perception
11	466643	OD	71	Unchanged	136	Unchanged	..	..	
					137	Unchanged	..	..	
					140	No light perception	4	..	No light perception
12	457018	OD	73	Unchanged	146	Unchanged	2	..	Unchanged
13	411857	OD	86	Unchanged	133	Unchanged	2	..	Unchanged
14	371425	OS	88	Unchanged	142	Unchanged	2	..	Unchanged
15	487454	OS	80	Decreased	139	No light perception	2	..	No light perception
16	847335	OD	91	Unchanged	144	No light perception	2	..	No light perception

TABLE 12.—*Visual Results in Cases of Multiple Corneal Transplantations—Continued*

Case No.	Clinic No.	Eye	Initial Transplant: Operation No.	Initial Transplant: Visual Acuity	Secondary Transplant: Operation No.	Secondary Transplant: Visual Acuity	Totals: Eye	Totals: Patient	Final Visual Acuity *
17	565344	OD	96	Unchanged	153	Unchanged	2	..	Unchanged
18	624147	OD	100	Decreased	156	Unchanged	2	..	Decreased
19	439832	OS	109	Unchanged	135	No light perception	2	..	No light perception
20	573564	OS	121	Decreased	151	Decreased	2	..	Decreased
21	764672	OS	124	Unchanged	160	Unchanged	2	..	Unchanged
Totals									
21 patients		21	Improved 0		Improved 0		44 grafts		Improved 0
			Unchanged 11		Unchanged 14				Unchanged 7
			Decreased 10		Decreased 8				Decreased 13
			—		Unknown 1				Unknown 1
			Totals 21		—				—
					Total 23				Total 21
Grand Totals (Bilateral and Unilateral Transplants)									
			Visual Acuity		Visual Acuity				
41 patients		61 eyes	Improved 12		Improved 2		101 grafts		Improved 13
			Unchanged 28		Unchanged 22		5 (not in		Unchanged 17
			Decreased 21		Decreased 11		— series)		Decreased 26
			—		Unknown† 5		96 grafts		Unknown† 5
			Total 61		—				—
					Total 40				Total 61

* Not necessarily the same as the visual result of the last operation. This column contains evaluation of the final visual result based on comparison with vision before the first operation. This applies only to patients having secondary corneal transplantations.

† These 5 secondary operations are part of the 17 operations excluded from the series because the patients had not been followed for six months. They are included here to complete the record of multiple operations and to explain the outcome of the first transplantations on these 5 eyes.

8 eyes; no significant change in acuity, 36 eyes, and decreased visual acuity, 25 eyes. A comparison of the results in these two groups is shown in table 13. The fact that the visual results per eye operated on were better in the multiple graft group than in the group having a single transplant suggests that repeated transplantations may yield better results than single opertaions. Therefore, the visual results in the 130 eyes were surveyed so as to compare the results of single operations with the final outcome of multiple operations. Table 12 contains the data on the 37 eyes that had more than one corneal transplant and on 24 eyes that had a single graft; the latter group was combined with the 69 eyes not in the multiple operation series, making a total of 93 eyes with a single corneal graft. The results of this comparison are also shown in table 13. Only 1 of the 37 eyes that had two or more transplantations showed improved vision; 11 eyes in this group showed no significant change, and 20 eyes had a loss of vision. The results in the 93 eyes that had a single transplantation were better: improved visual acuity, 20 eyes; no significant change in acuity, 42 eyes, and loss of visual acuity, 31 eyes. It is thus evident that, although the results per eye operated on were better in the multiple operation group, the good results were not due to repeated grafts on the same eye. For some undetermined reason, the 20 patients with bilateral transplantations obtained better visual results than the rest of the patients, although 12 of the 13 successful results in this group occurred in eyes with a single transplantation.

Results on the Basis of Patients.—In the group of 20 patients who had bilateral corneal transplantations (part A of table 12), 7 patients had 1 graft on each eye, 9 patients had 3 grafts on two eyes; 1 patient had 1 graft on one eye and 3 grafts on the other eye, and 3 patients

TABLE 13.—*Analysis of the Visual Results per Eye with Corneal Graft*

	Number of Eyes	Number of Grafts	Visual Acuity			
			Improved	Unchanged	Decreased	Unknown
A. Comparison of Results in Patients Having One Graft with Results in Patients Having Multiple Grafts						
Results per eye in patients with one graft	69	69	8	36	25	..
Results per eye in patients with multiple grafts	61	101	13	17	26	5
Totals	130	170	21	53	51	5
B. Comparison of Results in Eyes According to Number of Transplantations						
Results in eyes with only one graft	93	93	20	42	31	..
Results in eyes with more than one graft	37	77	1	11	20	5
Totals	130	170	21	53	51	5

TABLE 14.—*Visual Results in Patients with Bilateral Corneal Transplantation*

Final Visual Result (Visual Acuity)	Patients with One Graft on Each Eye	Patients with Three or More Grafts on Two Eyes	Totals	
Improved				
Improved in both eyes	3	..	3	10
Improved in 1 eye and unchanged in other eye	1	1	2	
Improved in 1 eye and decreased in other eye	2	3	5	
Unchanged				
Unchanged in both eyes	..	3	3	3
Decreased				
Unchanged in 1 eye and decreased in other eye	1	1	2	5
Decreased in both eyes	..	3	3	
Unknown	..	2	2	2
Totals	7	13	20	20

had 2 grafts on each eye. The final visual results for these patients with bilateral transplantations are shown in table 14. If improved visual acuity in either one or both eyes is considered a successful result, and a decrease in visual acuity in either eye (unaccompanied with improved visual acuity in the other), a loss of vision, the results in these 20 patients can be classified by the same standards as were the results of the operations and the visual acuity according to eyes, indicated in the preceding sections. Thus, 10 patients obtained improved vision, and

3 showed no significant change in visual acuity. Five patients showed a loss of vision, and the result was unknown in the remaining 2 patients.

The results in the group of 21 patients who had more than 1 corneal transplantation on one eye (part B of table 12) were uniformly poor. None of these patients obtained improvement in vision. There was no significant change in visual acuity in 7 patients, and visual acuity was decreased in 13 patients. The result was unknown in 1 instance. Seven of these patients, or one third of the group, lost all light perception in the eye operated on.

The results in the group of 69 patients who had only 1 transplantation on one eye are obtained from tables 2 to 8; the final visual results were as follows: improved vision, 8 patients; no significant change in visual acuity, 36 patients, and a loss of vision, 25 patients.

The final visual results for the 110 patients, arranged according to the number of transplantations on each eye, are tabulated in table 15.

TABLE 15.—*Visual Results of Corneal Transplantation in 110 Patients*

Number of Operations per Patient	Number of Patients	Final Visual Acuity			
		Improved	Unchanged	Decreased	Unknown
One graft on one eye	69	8	36	25	..
Two or more grafts on one eye	21	..	7	13	1
One graft on each eye	7	6	..	1	..
One graft on one eye and two or more on the other eye	10	4	2	4	..
Two or more grafts on each eye	3	..	1	..	2
Totals	110	18	46	43	3

Eighteen patients, or 16 per cent of the series, obtained improvement in vision to better than 20/200 visual acuity in one or both eyes. There was no significant change in vision in 46 patients, or 42 per cent of the series. There was loss of vision, or a decrease in visual acuity in one or both eyes, in 43 patients, or 39 per cent of the series. The final visual result in 3 patients was unknown.

CONCLUSIONS

1. There is no accord in the ophthalmologic literature concerning the results of corneal transplantation.

2. Transparency of the graft cannot be considered adequate proof of a successful operation, because clear grafts are frequently seen without any functional improvement in the eye. Normal corneal curvature is as important as clarity of the graft in obtaining a successful optical result.

3. Improvement in vision is the logical index of success in corneal transplantation. Inasmuch as 20/200 visual acuity is commonly accepted as the threshold for industrial blindness, it is suggested that

successful results in corneal transplantation require postoperative improvement in visual acuity to better than 20/200.

4. The visual and cosmetic results of 165 corneal transplantations, performed on 130 eyes of 110 patients, are reviewed:

(*a*) Visual acuity was improved to better than 20/200 after 22 operations, or 13 per cent of the series. There was no significant change in visual acuity after 86 operations, or 52 per cent of the series. A loss of visual acuity followed 57 operations, or 35 per cent of the series; 20 of these operations, or 12 per cent of the series, were followed by loss of light perception.

(*b*) Best results were obtained in cases of keratoconus; 10 of the 22 successful operations occurred in the keratoconus group.

(*c*) Poorest results were obtained in cases with chemical burns of the cornea; none of these operations were successful.

(*d*) The results of secondary corneal transplants were also poor; only 2 of the 35 operations in this group resulted in improved vision. Eight of these secondary operations resulted in loss of light perception.

(*e*) Fifteen of the 22 eyes with postoperative improved visual acuity required strong minus lenses to attain this acuity. This postoperative myopia is evidence of a marked tendency of the cornea to bulge after a corneal transplant.

(*f*) Clear grafts occurred twice as often as improvement in vision in this series of operations.

(*g*) The average follow-up period for the entire series of operations was 37.7 months.

5. The final visual results in the 130 eyes undergoing corneal transplantation in this series were: improved vision, 21 eyes (16 per cent); no significant change in vision, 53 eyes (41 per cent); loss of vision, 51 eyes (39 per cent), and result unknown, 5 eyes (4 per cent).

(*a*) Results were better in the eyes with a single transplantation than in the eyes that had multiple grafts.

6. The final visual results on the basis of the 110 patients were as follows: improved vision, 18 cases (16 per cent); no significant change in vision, 46 cases (42 per cent); loss of vision, 43 cases (39 per cent), and unknown result, 3 cases (3 per cent).

(*a*) Best results were obtained in those patients who had bilateral corneal grafts. Ten of the 20 patients in this group achieved improvement in visual acuity to better than 20/200. Three of these 10 cases obtained successful results in both eyes.

Permission to use the case histories in this report was given by Dr. John H. Dunnington, Director of the Institute of Ophthalmology of the Columbia University-Presbyterian Hospital Medical Center, New York.

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Correspondence

RETROLENTAL FIBROPLASIA

To the Editor:—There is, at present, enough confusion on the disease entity "retrolental fibroplasia" in the literature. Unfortunately, in my opinion, this is being further added to by the use of the term "coloboma," which has appeared in a recent article, in the June 1949 issue of the ARCHIVES.

Paul, in "Blood Groups and Effects of Roentgen Irradiation in Retrolental Fibroplasia," writes (page 664, case 7): ". . . a falciform fold of the retina in each eye. There was a coloboma of the optic nerve in the left eye." The author stated that he saw a coloboma. It is quite possible that he did. However, I doubt it, for I have watched several of these enlarged optic disks develop. It is my belief that they occur in the majority of cases of retrolental fibroplasia and that they represent a regular stage of the disease. They can be observed especially in those cases in which development does not progress further than a retinal fold. They can also occasionally be observed in a carefully followed case before the vitreous becomes cloudy or a developing retrolental membrane separating from the ora serrata obscures the details of the fundus.

Briefly, as the fold develops, traction produces blurring of the side of the disk adjacent to this. After a short period (a few days to several weeks, depending on the speed of the disease) a pigmented semicircle begins to appear in the retina on the far side of the disk. This pigmentation is due, I believe, to a localized separation of the retina around the disk resulting from the traction, carrying with it the retinal pigment layer, and is not due to actual pigment. At the edge of this separation, the elevation of the retinal pigment layer almost doubles, so that the area becomes dark. The disk now appears enlarged two, three or four times. The disk and the adjoining retina are elevated from traction. The distribution of the central retinal vessels is still normal. The blood vessels can be followed down into the surrounding retina. Shortly thereafter, further traction distorts the position of the blood vessel on the disk. The outlines of the disk can no longer be identified as such. There remains an enlarged, pale orange to whitish area from which a caput medusa of vessels arises, some vessels going to the retina proper, others running up on the fold.

It is my hope that the term "coloboma" will not enter in the description of retrolental fibroplasia. What has occurred is a postnatal elevation of the disk and surrounding retina, as I have outlined. A coloboma of the disk is a congenital anomaly in which the disk has failed to develop, having a grayish white hole of varying depth and size.

JULIAN F. CHISHOLM JR., M.D., Boston.

34½ Beacon Street (8).

MECHANICS OF INTRACAPSULAR CATARACT EXTRACTION

To the Editor:—For the benefit of those who read the paper entitled "Mechanics of Intracapsular Cataract Extraction," by Dr. David O. Harrington, published in the July 1949 issue of the ARCHIVES, I wish to call attention to a slight error. He credits Horner with the introduction of lid sutures in the cataract operation. Evidently he had overlooked my paper read at the meeting of the Chicago Ophthalmological Society in January 1934, and published in the *American Journal of Ophthalmology* in September 1934, from which the following paragraph is quoted:

> Upper-lid sutures (fig. 1). Two are used, spaced in the middle of each half of the upper lid. They include the skin only and are placed just above the lash line. The ends are arranged to give an even lift and grasped by a hemostat which is dropped over the top of the head. In many instances this gives all the needed lift and no elevator is required. They permit perfect control in closing the eye after operation and are then fastened to the cheek by adhesive plaster thus holding the temporarily paralyzed lids in apposition. They also afford perfect control at the dressings, as lid lifters, making it unnecessary even to touch the lids.
>
> Speculum. I never use one.

I had used these sutures for many years. The need for them is so obvious that it never occurred to me that their use was original.

RODERIC O'CONNOR, M.D., Oakland, Calif.
411 Thirtieth Street (9).

News and Notes

EDITED BY DR. W. L. BENEDICT

GENERAL NEWS

Mark J. Schoenberg Memorial Lecture.—The Mark J. Schoenberg Memorial Lecture was held at the New York Academy of Medicine at 8:30 p. m., Monday, December 5, under the joint sponsorship of the New York Society for Clinical Ophthalmology and the National Society for the Prevention of Blindness. Dr. Jonas S. Friedenwald, of Baltimore, discussed "Problems in the Diagnosis and Treatment of Glaucoma."

This lectureship was established as a memorial to Dr. Schoenberg's interest and original work in the control of glaucoma.

The committee in charge of arrangements for the meeting was composed of Willis S. Knighton, M. D., chairman; Isadore Givner, M.D.; James W. Smith, M.D., and Franklin M. Foote, M.D.

Nineteenth Annual Midwinter Postgraduate Clinical Convention of the Research Study Club of Los Angeles.—Among the guest speakers at the nineteenth annual midwinter postgraduate clinical convention of the Research Study Club of Los Angeles, Jan. 16-27, 1950, will be Dr. Conrad Berens and Dr. Raymond Meek, both of New York, and Dr. Meyer Wiener, of Coronado, Calif. In addition, there will be didactic lectures and instruction courses, given largely by representative teachers of the Pacific Coast.

Research Grants Offered by The National Council to Combat Blindness.—This organization, which was established for the purpose of financing and stimulating ophthalmologic research, is now offering grants in aid to scientific investigators. Applications to be considered for the first group of awards should be in the office of the Council by Feb. 15, 1950. Application forms may be obtained by addressing the secretary, National Council to Combat Blindness, Inc., 1186 Broadway, New York 1.

Annual Arthur J. Bedell Lecture.—Dr. Francis Heed Adler will deliver the annual Arthur J. Bedell Lecture on the evening of March 17, 1950, at the Annual Clinic Conference of the Wills Eye Hospital, Philadelphia.

SOCIETY NEWS

Hawaii Eye, Ear, Nose and Throat Society.—The society held its opening fall meeting at Tripler General Hospital, Honolulu, Territory of Hawaii, on Sept. 15, 1949.

The professional program comprised the following papers: "An Evaluation of Methods of Treatment in 155 Cases of Pterygium," by Lieut. Col. John H. King Jr., with discussions by Drs. Forrest J. Pinkerton, Ogden D. Pinkerton, H. F. Moffat and Philip M. Corboy; and a case report on "Esophageal Stenosis," by Major Aubrey K. Brown, with discussions by Drs. John P. Frazer, L. Q. Pang and Clarence J. Kusunoki.

Reading Eye, Ear, Nose and Throat Society.—The Reading Eye, Ear, Nose and Throat Society, Reading, Pa., elected the following officers for the year 1949-1950: president, Dr. William J. Hertz, Allentown; first vice president, Dr. John M. Wotring, Reading; second vice president and president elect, Dr. Roy Deck, Lancaster; treasurer, Dr. Philip R. Wiest, Reading; secretary, Dr. Paul C. Craig, Reading, and program chairman, Dr. C. Fremont Hall, Phoenixville, Pa.

New Orleans Ophthalmological Society.—The following officers have been elected: president, Dr. George M. Haik; secretary-treasurer, Dr. N. Leon Hart.

PERSONAL NEWS

Prof. Josef Meller's Seventy-Fifth Birthday.—The occasion of Prof. Josef Meller's seventy-fifth birthday, on October 22, makes this an appropriate time to recognize what he has done for ophthalmology and to speak of many qualities which have made him outstanding. With an inexhaustible capacity for work, he took full advantage of the opportunities offered in Fuchs's clinic in those eventful days of the Vienna school and rapidly advanced, entirely on his own efforts, so that he was ready to carry on in the best tradition of Austrian ophthalmology when the occasion presented itself. As chief of the first ophthalmologic Clinic in Vienna, he proved to be an admirable organizer; he took his profession very seriously, with the persistent aim to uphold its high tradition.

He soon made his mark as a teacher. His unusual command of descriptive language and clarity of expression make him a forceful and interesting speaker. His diction is most comprehensive, with careful regard to grammar and with just the right touch of humor. As a writer he is clear and concise. His many years as one of the editors of the *Zeitschrift für Augenheilkunde* meant many hours of hard work, and he was proud of the admirable way in which he transformed this journal to one of the leaders in the field of ophthalmology; for this reason, the

unhappy way in which his cooperation was brought to a close was particularly distressing.

His investigations have been principally along the line of pathology, and his publications have covered many sides of this important field. As a surgeon, his dexterity was striking, and the soundness of his judgment was as impressive. The many who have profited by his operative courses will never forget the debt he has placed them under. His textbook on ophthalmic operations (Augenärztliche Eingriffe: Ein Kurzgefasste Operationslehre, Vienna, Julius Springer, 1946) is the best of

JOSEF MELLER

its kind and cannot be surpassed as an introduction to this difficult art of surgery. It remains an indispensable source of accurate information.

To anticipate the publication of a *Festschrift* at his sixtieth year, he reversed the usual procedure and gathered together some of his publications and speeches in a book entitled "Ausgewählte Schriften und Reden," which he sent to his friends.

A kindly and agreeable personality, he has great charm of manner and grace, and his forthcomingness draws men to him. His culture is wide; he not only is a gifted musician but he keeps up his love of the classics, especially of Horace, whose book of poems has been his constant

and faithful companion through life. He usually passed his spring vacation in Italy, and the summer holidays found him in the beautiful Marienbad region, enjoying the many walks in the pine forests but always ready when the weather turned to rain to study microscopic slides with the aid of his invariably present microscope.

In his partial retirement, let us wish him many years of good health and the maintenance of his interest in the problems of ophthalmology.

Society Transactions

EDITED BY DR. W. L. BENEDICT

OPHTHALMOLOGICAL SOCIETY OF THE UNITED KINGDOM

A. J. Ballantyne, M.D., *President*

James H. Doggart, M.D., and E. F. King, M.B., *Secretaries*

James H. Doggart, M.D., *Reporter*

Sixty-Seventh Annual Congress, March 27, 28 and 29, 1947

The Sixty-Seventh Annual Congress of the Ophthalmological Society of the United Kingdom was held in the department of zoology of Glasgow University on March 27, 28 and 29, 1947, under the presidency of Prof. A. J. Ballantyne, LL.D., M.D., F.R.F.P.S., who delivered an address of welcome to the members and guests, especially to those who came from abroad, namely, Dr. P. Mérigot de Treigny (Paris), Prof. W. H. Melanowski (Warsaw), Dr. J. van Canneyt (Ghent), Dr. Erik Godtfredsen (Copenhagen), Madame Suzanne Valons (Paris) and Madame Schiff-Wertheimer (Paris).

De Senectute. Prof. A. J. Ballantyne.

Under this title, the president delivered an address full of wit and mellow wisdom. He maintained that, although living organisms must sooner or later come to an end, there is good reason to hope that many of the disintegrative processes which now beset us may in time be retarded or modified. The fact that people exhibit such variability in the rate of their decline that even in one and the same body the changes of age so often afflict the separate organs at very different periods and that such discrepancies in the time table can seldom be foretold with accuracy ought to make one realize the complexity of senile change.

Dr. Ballantyne stressed the prevalence of fear among patients with cataract but pointed out that in many instances a simple, encouraging talk by the surgeon is enough to allay such apprehensions. He proceeded to underline the disadvantages of rule of thumb methods in the correction of presbyopia and especially deprecated overcorrection. His closing sentences drew attention to the numerous ways in which older people can continue to give valuable service to the world, but he strongly advocated free scope for the younger generation. Dr. Sinclair's vote of thanks for the address was warmly received by an audience containing many of Dr. Ballantyne's former pupils, who have reason to remember his happy knack of encouraging the young. They know that he, for one, will never lapse into crabbed age and that he will continue to illuminate whatever clinical and pathologic territory may attract his attention in years to come.

DISCUSSION SESSION

The subject chosen for discussion was, "Rhinology in Relation to Ophthalmology." Dr. J. Marshall, the first opener, pointed out that in dealing with so wide a subject the openers had felt bound to limit the

range of discussion. They had therefore agreed to ignore the controversial question whether, and to what extent, inflamed nasal sinuses might be regarded as a focus of origin of intraocular inflammation or retrobulbar neuritis. Dr. Marshall went on to stress the ophthalmic surgeon's duty of close collaboration with the rhinologist in cases of orbital inflammation, because nasal treatment in many instances offers the best chance of cure. Although he recognized the value of sulfonamide compounds and penicillin, he insisted that these drugs should be used with discrimination, and only after careful review of the clinical signs in each case. Dr. Marshall emphasized the advantages of Dandy's transfrontal approach over the Krönlein operation as a method of exploration for intraorbital neoplasms, because these growths often extend into the cranial cavity. He then referred appreciatively to the work of Dr. Godtfredsen on the ocular symptoms and signs of nasopharyngeal growths. Dacryocystorhinostomy was enthusiastically mentioned by Dr. Marshall, who emphasized that most of the modifications in technic advocated by various operators are of secondary importance. The chief desideratum was the creation of a sufficiently large opening into the nose.

Mr. E. H. Howells, the otorhinolaryngologic surgeon at Moorfields Eye Hospital, was the second opener of the discussion. He gave detailed consideration to the acute and chronic inflammatory disorders of the accessory air sinuses and drew attention to the mechanisms by which infection may spread from one group of cells to another, and thence to the orbit. The direction of proptosis, he suggested, will often provide a clue to which sinus is implicated, but signs may be equivocal. Absence of or trivial symptoms may coexist with severe infection. Aching, when a prominent feature, will often observe a remarkable periodicity, so that some patients can almost set the clock by the onset of neuralgic pain at a regular time of day. Mr. Howells mentioned that the diplopia which follows so large a percentage of operations on the frontal sinus spontaneously subsides in the majority of cases. He also reminded listeners that, although the frontal sinus is rudimentary until the age of 6 years, serious inflammation can arise therein before that age. In dealing with neoplasms, Mr. Howells stressed the advantages of roentgen therapy and the difficulties of surgical intervention. He drew particular attention to the devastating hemorrhage issuing from benign angiofibromas of the nasopharynx if they are touched with a knife. Dacryocystorhinostomy, he said, was not feasible in the management of patients less than 5 years old. Among the nasal conditions interfering with drainage of tears he mentioned hypertrophic rhinitis, lupus and syphilis, as well as trauma resulting from unskilled antrostomy.

Dr. R. McWhirter, representing the roentgenologists, showed a number of excellent pictures illustrating the clinical and roentgenologic features of neoplasms of the accessory sinuses. Diagnosis of such growths is often delayed by their propensity to produce benign polypi as a subsidiary effect. Moreover, these tumors are so rare that the average family physician is unlikely to see more than one or two in the course of thirty years' practice. A common error is to make the diagnosis of disease of the hemopoietic system in young people exhibiting bilateral glandular enlargement in the neck deep to the posterior margin of the sternocleidomastoid muscle, whereas the true diagnosis will

often prove to be a malignant neoplasm of the nasopharynx. He went on to emphasize that so-called nasopharyngeal endothelioma is in reality a carcinoma of the sphenoid sinus, the first manifestation of which may be an ocular palsy. Early stages of this condition respond satisfactorily to roentgen therapy.

During the brief time that remained for discussion at the end of these opening papers, Prof. W. H. Melanowski spoke on orbital cellulitis, which was, in his experience, always due to sinus disease. He also showed pictures to illustrate proptosis resulting from neoplasms of the sinuses and orbit. Dr. Erik Godtfredsen stressed the dangers that beset the orbital contents from the ill directed use of forceps and tamponage in rhinologic operations. He also touched on the differential diagnosis of nasopharyngeal growths and tumors arising in the accessory sinuses. Finally, Mr. B. W. Rycroft claimed benefit from continuous intubation of the nasolacrimal duct in certain cases of deranged tear flow.

PAPERS OF THE CONGRESS

Induction of Experimental Tumor of the Lens. PROF. IDA MANN.

This paper was amply illustrated by pictures of tissue cultures. Having considered the possible reasons that carcinoma of the human lens has never been observed, Professor Mann went on to suggest that nonvascularity would appear to be the most likely explanation. Experimental evidence supports such a theory, for cancer has now been produced in a transplanted lens by controlled tissue culture once the displaced organ has had time to acquire a blood supply. The audience was reminded that all known species share a common organ-specific lens protein. In the course of the subsequent discussion, Professor Mann was congratulated by more than one speaker, and Mr. R. A. Greeves remarked on a similar immunity of the nonvascular cornea to malignant growths.

An Unusual Form of Retinal Detachment (Cystic?) Seen in Children. MR. F. A. JULER.

The 3 cases described were of children with defective central vision. The retinal detachments were nonprogressive or very slowly progressive and were situated in the lower periphery of one or both retinas. Hemorrhage into the vitreous and large oval rents in the retina were other characteristics. According to Mr. Juler, such cases carry a bad prognosis, and operation is of doubtful value.

Professor Mann agreed with Mr. Juler that cases of this type are not suitable for operation. She maintained that such cysts are in reality intraretinal, so that they are not genuine instances of retinal detachment. Professor Mann also stressed the influence of heredity as an etiologic factor in cysts of the retina.

Mr. C. D. Shapland mentioned a case in which iridocyclitis followed rupture of a retinal cyst. [In this connection, the reporter wishes to remind readers of similar effects produced by the sudden release of crystals, the irritant capacity of which may have remained dormant during long years of enclosure of the crystals within the lens capsule or adventitious intraocular membrane.]

Epiphora: Diagnosis and Treatment. Dr. H. M. Traquair.

Nearly every ophthalmic surgeon is interested in epiphora, which has many causes and shows wide individual variations in its response to treatment. With respect to the etiologic significance of intranasal infection, mentioned by several speakers, Dr. Traquair, in his final reply, stated that the nasal condition did not appear to affect his results in the operation of dacryocystorhinostomy so long as he created an adequate opening into the nose.

Lid and Socket Repair. Mr. J. Scott Tough.

The author deprecated premature plastic operations and emphasized the importance of hemostasis. He went on to discuss the technic of Z plasty, Imre flaps and Blascovicz rotation flaps. He dwelt on the difficulties of enlarging a contracted socket through plastic surgery and described the value of sustained stretching, rendered possible by splints attached to plaster caps or to the teeth.

Bilateral Retinal Detachment Associated with Choroidal Cyst. Dr. J. Pendleton White and Dr. I. C. Michaelson.

The authors invited suggestions concerning treatment for a woman aged 56 whose retina had undergone temporary replacement after a scleral trephination on her only remaining eye. The other eye had been enucleated after development of complicated cataract, and sectioning had revealed general edema of the choroid, together with a large choroidal cyst opposite the globular portion of the retinal detachment. No inflammatory signs had been detected in either eye. Suggestions for treatment made by subsequent speakers included cyclodialysis and the injection of sclerosing fluid.

Blood Staining of the Cornea. Prof. A. Loewenstein.

The author gave an account of 5 cases, in 2 of which the staining was preceded by iridectomy. Of the other 3 instances, in which blood staining arose spontaneously, malignant intraocular growths were present in 2. Professor Lowenstein's paper was illustrated by pictures of microscopic sections. He stressed the importance of a persistent breach of Descemet's endothelium and membrane in the production of blood staining and drew attention to the profound disturbance of corneal metabolism consequent on prolonged imbibition of fluid by the interlamellar spaces of the substantia propria. He reminded his listeners that atropine is contraindicated in such cases.

This paper was discussed by several speakers, including Mr. F. A. Juler, who claimed to have seen blood staining in corneas the endothelium of which was intact. Rupture of deep corneal vessels was mentioned by Mr. J. H. Doggart as a relatively benign form of corneal blood staining. Mr. M. H. Whiting emphasized the desirability of evacuating hyphemas persisting as long as a week, especially after cataract extraction.

Reiter's Disease: Report of a Case. Mr. R. Lindsay Rea.

In Reiter's original case the picture was that of polyarthritis, urethritis and conjunctivitis, but Mr. Rea's patient, a man aged 29, had bilateral iridocyclitis. The latter complication responded well to heat

and atropine, but a diagnosis of retrobulbar neuritis of the right eye was made five months later, and the condition persisted for three months. Various explanations of Reiter's disease have been put forward, and its origin is uncertain. [The reporter cannot refrain from putting the question: "Is Reiter's disease a clinical entity?"]

Relation of Sjögren's Disease, the Plummer-Vinson Syndrome (Hypochromic Anemia), and Ariboflavinosis. DR. ERIK GODTFREDSEN.

On the basis of a series of 23 patients, all women, with Sjögren's disease, the author concluded that, in spite of many common lesions, especially in epithelial structures, Sjögren's disease is a distinct entity, and not merely a variant of ariboflavinosis or of the Plummer-Vinson syndrome. He stressed the danger of irritant applications to the cornea in cases of Sjögren's disease.

Holes in the Optic Disk, with Particular Reference to Changes in the Visual Field. MR. HUMPHREY NEAME.

The author illustrated his report of 9 cases with a number of pictures. Charts of visual fields were shown, and Mr. Neame speculated concerning the mechanism and rationale of the various field defects that may occur in this condition.

Self-Inflicted Injuries to the Eyes. DR. L. B. SOMERVILLE-LARGE.

On the basis of his experiences with 360 cases among Indian troops in 1942 to 1945, the author emphasized that, although medical men accustomed to work in India were well acquainted with such lesions, and he himself soon became familiar with them, yet at first he had been mystified by encountering lesions different from anything within his previous experience. He showed pictures of the ocular signs and of the melancholy facial expressions of victims of self-inflicted injury, and he specially mentioned jequirity seeds and fragments of castor oil seeds as the favorite means of producing lesions in the eye. The main clinical features were (*a*) membranous palpebral conjunctivitis, chiefly of the lower lids; (*b*) a corresponding lesion of the opposing area of bulbar conjunctiva; (*c*) enlargement of the ipsilateral preauricular lymph node, and (*d*) edema of the eyelids. The patients rapidly responded to simple remedies, and symblepharon rarely supervened, except in cases of repeated self infliction of injury. Careful search of the victim's kit usually unearthed a supply of spare seeds.

During the subsequent discussion, Dr. P. Mérigot de Treigny mentioned the ingenious simulation of trachoma on the part of French prisoners deported to work in Germany. These determined opponents of the Reich would produce an alarming crop of follicles by rubbing the upper fornix with an aperient pill, thus insuring repatriation. Dr. H. M. Traquair referred to the employment of aluminum turnings by Continental fanatics endeavoring to produce bloody tears. Mr. R. C. Davenport testified to the occurrence of many cases of similar self-inflicted injuries among Indian troops in France during the First

World War. It should be emphasized that Dr. Somerville-Large's cases all occurred among troops stationed at bases remote from active fighting.

Vision During Glancing Movements of the Eyes. Dr. G. H. Bell and Dr. J. B. de V. Weir.

The authors dwelt on the importance of proprioceptive impulses elsewhere in the body as a vital accompaniment of sight. For this reason alone, they contended, the cinema could never supply an utterly satisfactory illusion. To take a simple instance, a screen representation of someone walking up a hill must always remain, so to speak, merely conventional, because no demands are made on the spectator's back and limb muscles. The selective importance of suppression was emphasized, and reference was made to certain experimental difficulties, e. g., the wide variation of response among different subjects, and the difficult task of analyzing phenomena that change every fraction of a second. At any rate, the eye is not a mere camera, and visual images cannot be completely explained in terms of geometry. The cerebral cortex must have its say.

Concussion Injury to the Eye. Dr. A. M. Wright-Thomson.

The author analyzed 32 cases encountered during his four years' captivity by the Japanese. He showed a number of pictures and suggested that spasm of the retinal vessels produced by an axon reflex from the choroidal lesion offered the most probable explanation of the clinical signs in such cases. The undoubted existence of traumatic vascular spasm elsewhere in the body was, he said, indirect evidence in support of such an explanation. Changes in tension can easily be interpreted on a similar basis.

Cysticercus Cellulosae of the Eye. Prof. W. H. Melanowski.

Schnabel's Cavernous Atrophy. Mr. Eugene Wolff.

This disease, in the author's opinion, is a classic example of the effect of gradual cutting off of blood supply from the optic nerve, producing degeneration of the nerve fibers before that of the supporting connective tissue. Until the glial tissue disappears, which it ultimately does, histologic preparations reveal intact scaffolding, as though the contained nerve fibers had undergone dissolution by a corrosive. Several beautiful illustrations were shown, and Mr. Wolff reminded his listeners that the strength of the lamina cribrosa exhibits considerable variation in individual persons, so that a certain degree of increased tension, persisting for any given time, may easily produce excavation in the disk of one man and leave his neighbor's uncupped.

Aspects of Disease Affecting the Retinal Veins. Prof. A. J. Ballantyne and Dr. I. C. Michaelson.

The chief conditions mentioned were venous obstruction, Eales's disease and diabetic retinopathy. Although the etiologic factors differ in these three states, and although they typically occur in different age groups, yet the diseases exhibit much in common and may closely resemble each other when far advanced. In all three conditions abnor-

mality of larger veins tends to emerge in the form of sheathing and variation in caliber. Capillary changes are apt to be manifested as hemorrhages, microaneurysms, microexudates and formation of new vessels. Cellular infiltration of the vascular wall is the basis of sheathing in Eales's disease, but anoxemia may produce a similar phenomenon. The stages of diabetic retinopathy were summarized. Dr. Michaelson, who read the paper, gratefully acknowledged the congratulations of Mr. Humphrey Neame and Mr. Eugene Wolff, and went on to mention the joint indebtedness of Dr. Ballantyne and himself to Professor Loewenstein's skill in the histologic preparation of flat sections of the retina.

The paper was amply illustrated.

CLINICAL MEETINGS

On the second day of the congress, a clinical meeting was held at the Glasgow Eye Infirmary, under the chairmanship of Dr. Spence Meighan, the president of the Scottish Ophthalmological Club. About 30 cases were presented, representing a number of bizarre results of trauma, together with several rare conditions, such as hypertelorism. An interesting discussion of the cases followed.

ANNUAL GENERAL MEETING

Although the routine business of the Society need not be detailed here, the reporter wishes to record that the new treasurer of the Society, Mr. Frank Law, paid tribute to the memory of Sir Arnold Lawson, who died last January, after serving continuously as treasurer for twenty-eight years.

At the close of the Congress, Dr. W. Clark Souter, of Aberdeen, congratulated Dr. Ballantyne on his successful first year of presidency and, after suggesting "de Amicitia" as an alternative title for the presidential address, requested that the president should convey the warm greetings of the Society to those friends and colleagues whom he was soon to meet in the United States.

SOCIAL EVENTS

Some of the members paid an evening visit to a steel works. On the last afternoon an expedition was made to the Corporation of Glasgow Art Galleries, under the direction of Dr. T. J. Honeyman, a contemporary of the well known playwright James Bridie. Other members and guests visited, by invitation of the University Court, the Hunterian Museum of Glasgow University, which contains a fine collection of Whistler's works, as well as abundant pathologic specimens.

The annual dinner of the Society was held in the Hall of the Royal Faculty of Physicians and Surgeons of Glasgow. Sir Andrew Davidson proposed the health of the Society, and the president responded. The Toast of the Guests was proposed by Dr. Spence Meighan, and Dr. P. Mérigot de Treigny, of Paris, replied in excellent English. Finally, the health of the president of the Society was proposed by Sir Stewart Duke-Elder, who spoke with simple sincerity of the affection and esteem which the mention of Dr. Ballantyne evokes in the hearts of his friends all over the world.

Book Reviews

Blakiston's New Gould Medical Dictionary. First Edition. Editors: Harold Wellington Jones, M.D.; Normand L. Hoerr, M.D., and Arthur Osol, Ph.D. Pp. 1,294, with 252 illustrations on 45 plates, 129 in color. Price $10.75. Philadelphia: The Blakiston Company, 1949.

An editorial board and eighty well known contributors present an entirely new medical dictionary to replace the standard "Gould's Medical Dictionary," which has been so popular since its first edition in 1890.

It is difficult to evaluate a dictionary, especially since a reviewer has a bias toward his own specialty and a general medical dictionary is not intended as a reference book in any sense of the word. In spite of this, the present dictionary seems to have kept pace with most developments in the field of ophthalmology and includes items on gonioscopy, anomalous retinal correspondence, epidemic keratoconjunctivitis and many recent developments in the field of ocular therapeutics. Curiously, no mention is made of retrolental fibroplasia, which has general medical interest.

The illustrations are collected in 45 excellent plates, placed conveniently in the middle of the book. Many of these are in color. At the end of the definitions are a number of tables, including compilations of the arteries, veins, bones, joints, muscles, nerves and blood constituents; chemical data on diets, enzymes and hormones; lists of common pathogenic micro-organisms and symbols used in prescription writing. There is even a table of veterinary doses, which is particularly interesting because so many more crude drugs are used for animals than are now in use for man, the list ranging from aconitine to zingiber.

The paper and print are excellent. There is no doubt that this will be received with acclaim by the medical literary world, and the editors, contributors and publishers are to be congratulated on having produced such a beautiful, as well as functional, book.

F. H. Adler.

Physiology and Diseases of the Heart and Lungs. By M. D. Altschule, M.D. Price, $5. Pp. 368. Cambridge, Mass.: Harvard University Press, 1949.

This book contains no material which would be of direct application to ophthalmology, and yet it should be of interest to all ophthalmologists, especially those engaged in postgraduate teaching, as an excellent example of the application of basic science to clinical medicine. The author's field is cardiology, and he has chosen chronic cardiac decompensation as a clinical entity in which the details of cardiac and circulatory physiology are discussed.

There is an excellent bibliography at the end of each section. It is to be hoped that a similar monograph will appear some day dealing with an ophthalmologic disease entity, such as glaucoma. This book would be an excellent pattern to follow.

FRANCIS H. ADLER.

Manual for the Objective Examination of the Ocular Muscle Balance. By Beulah Cushman, M.D. Lithoprinted. Ann. Arbor, Mich.: Edwards Brothers, Inc., 1949.

This is a valuable monograph on methods of examination of the patient with ocular muscle anomalies and the various tests which can be employed to arrive at correct diagnosis. There are brief sections on the value of orthoptics and suggestions for surgical correction. The monograph is well documented with 36 case histories. It can be recommended to all who are interested in strabismus and will be particularly useful for the student preparing for the American Board of Ophthalmology examinations.

FRANCIS H. ADLER.

Proceedings of the All-India Ophthalmological Society. Volume IX. Madras Publishing House, Ltd., 1948.

This is a report of the ninth conference of the All-India Ophthalmological Society, held on March 11, 12 and 13, 1948 in Delhi. The conference was to have been held in January, but, owing to the death of Mahatma Ghandi, it was postponed.

FRANCIS H. ADLER.

The value of Hormones in General Practice. By W. N. Kemp, M.D. Price, $3. Pp. 115. Minneapolis: Burgess Publishing Company, 1949.

This monograph is mimeographed and covers in a fairly satisfactory manner recent knowledge concerning the subject of hormones in general practice. Many of the chapters will be of interest to ophthalmologists particularly those dealing with disorders related to the hypothalamus, the pituitary gland and the thyroid. The various pharmaceutical preparations that can be bought on the market are given at the end of each section, together with the specific dosage.

FRANCIS H. ADLER.

Ocular Signs in Slit-Lamp Microscopy. By James Hamilton Doggart, M.D. Price, $6.75. Pp. 112, with 93 illustrations, 85 in color. St. Louis: C. V. Mosby Company, 1949.

This is a short compilation of the changes seen in the anterior segment of the globe with the slit lamp. The colored plates are good, but not comparable to those already published in Vogt, Meesmann, Butler and Berliner's excellent atlases. The chief value of the book is the bibliography. The book is evidently intended to be used as a textbook for the beginner. For this purpose it can be well recommended.

FRANCIS H. ADLER.

Bulletin and Memoirs of the French Society of Ophthalmology. Paris: Masson & Cie, 1949.

This is a report of the sixty-first meeting of the French Society of Ophthalmology. The session of May 25, 1948 was given over to papers on keratoplasty. In the other four days, a total of fifty-six papers was presented, covering all fields of ophthalmology. These meetings of the French Society of Ophthalmology have been reported in some detail in another issue of the ARCHIVES.

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The index for volume 42 will be mailed with the January 1950 number.

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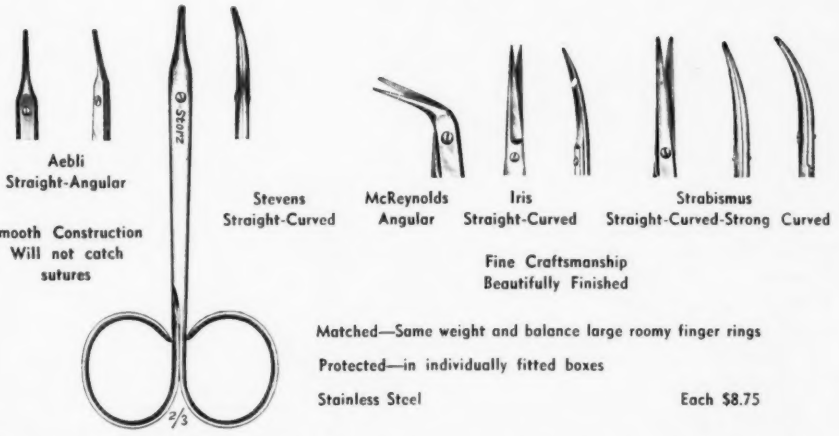

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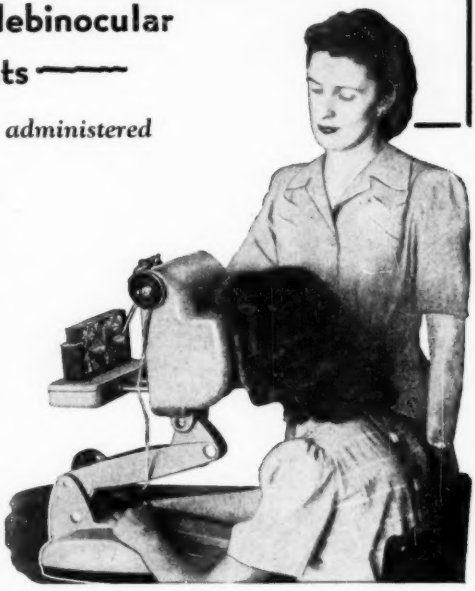

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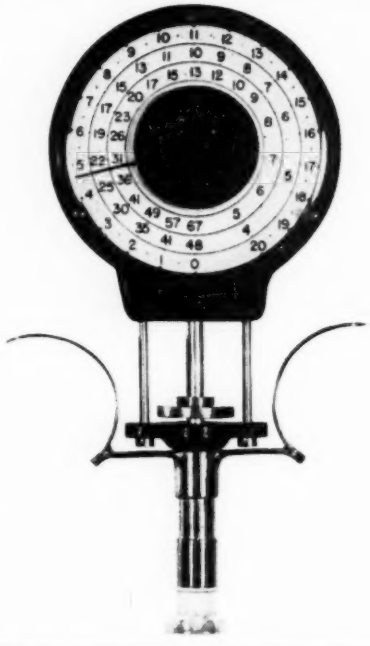

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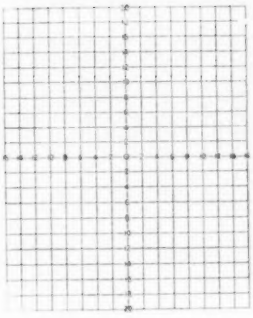

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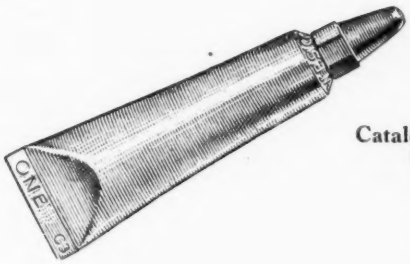

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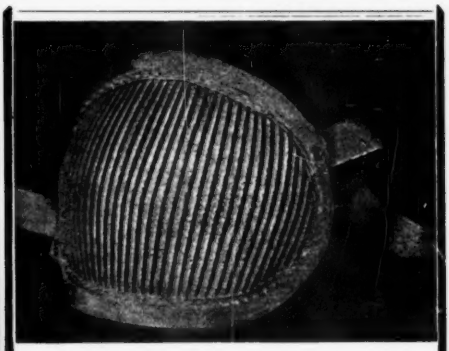

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